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ECONOMIC ANALYSIS OF EFFLUENT GUIDELINES

PETROLEUM REFINING INDUSTRY

ENVIRONMENTAL PROTECTION AGENCY

PREPARED FOR
SOBOTKA AND COMPANY, INCORPORATED

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16. Abstracts

The purpose of this document is to evaluate the potential economic impact on the United States petroleum refining industry of effluent limitation guidelines and standards of performance established by EPA pursuant to the Federal Water Pollution Control Act. The industry consists of some 240 plants owned by about 130 firms. Replacement value is in excess of $20 billion. Employees total about 150,000 persons. The costs of treating waste water have been determined by engineering studies, but the costs of in-plant reduction of waste water flow have not been estimated. However, it is known that combined cumulative capital investment through 1983 will be less than $1.8 billion (1974 prices), and that the average cost impact by 1983 will be less than one-half cent per gallon of refined product. Conclusions about the impact of these costs depend heavily upon the assumed form of government involvement in the industry. If U.S. refineries are allowed to compete domestically, but are protected from world competition, the impact may be negligible. Conversely, continuation of current controls on the margin (product revenue less crude costs) realized by large refineries may create problems for the many small refineries which will incur much greater unit cost increases than large plants.

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Pollution Abatement Costs
Waste Water Treatment

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ECONOMIC ANALYSIS OF EFFLUENT GUIDELINES

PETROLEUM REFINING INDUSTRY

December 1974

U.S. Environmental Protection Agency
Office of Planning and Evaluation
Washington, D. C. 20460

PREFACE

The attached document is a study prepared by Sobotka & Company, Inc., (Part I), and the Office of Planning and Evaluation of the U.S. Environmental Protection Agency (EPA), (Part II). Its purpose is to provide a basis for evaluating the potential economic impact of effluent limitations guidelines and standards of performance established by EPA pursuant to sections 304(b) and 306 of the Federal Water Pollution Control Act.

The study supplements an EPA technical "Development Document" issued in conjunction with the promulgation of guidelines and standards for point sources within this industry category. The Development Document surveys existing and potential waste treatment and control methods and technologies within this category and presents the investment and operating costs associated with various control technologies. This study supplements that analysis by estimating the broader economic effects (including product price increases, continued viability of affected plants, employment, industry growth and foreign trade) of the required application of certain of these control technologies.

The study has been prepared with the supervision and review of the Office of Planning and Evaluation of EPA. Part I of this report was prepared by Sobotka & Company and Part II by the Office of Planning and Evaluation of EPA. Work was completed as of April 1974 and slightly modified to bring it substantially up-to-date since then. The study is based primarily upon an earlier study, also prepared by the same authors, entitled, "Economic Analysis of Proposed Effluent Guidelines for the Petroleum Refining Industry." The earlier report was circulated in conjunction with the publication in the Federal Register of a notice of proposed rulemaking under sections 304(b) and 306 for the subject point source category. The analysis contained in

the original study has been updated based upon information received during the period of time between publication of the notice of proposed rulemaking and the promulgation of the final regulation. Because of the constraints of time, the control and treatment costs analyzed in this study may not in all instances be identical to those associated with the requirements of the promulgated regulation. However, those differences, when they exist, are minor insofar as the final conclusions of the study are concerned.

This report represents the views of the staff of the Office of Planning and Evaluation, EPA. It has been reviewed by the Office of Planning and Evaluation and approved for publication. Approval does not signify that the contents necessarily reflect the overall views of the Environmental Protection Agency. The study has been considered, together with the Development Document, information received in the form of public comments on the proposed regulation, and other materials in the establishment of final effluent limitations guidelines and standards of performance.

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PART I

INDUSTRY DESCRIPTION[1)]

1) This part of the report was prepared by Sobotka & Company, Inc.

INTRODUCTION AND SUMMARY

This is Part One of a two-part report. In this Part we present data and background information relevant to a consideration of the economic impact of pollution abatement costs on the petroleum refining industry.

Our choice of data and our description of the refining industry are influenced by two considerations. First, to present information valuable to persons who guide the making of public policy for this industry. Secondly, to discuss those aspects of the industry's relations with other industries which would be useful in assessing the impact of pollution abatement costs in the economy generally.

The petroleum refining industry in the United States consists of some 240 plants owned by about 130 firms and located in 39 of the 50 states. The refineries have a replacement value at current prices in excess of $20 billion. The refining industry employs about 150,000 persons.

The bulk of refining is done by firms which also market refined products or produce crude oil, or do both. In most firms the refining portion of the business is not its major activity. Refinery investment is less than 15 percent of total investment in the domestic oil industry. Refinery employment is a somewhat larger fraction of total employment. The industry has grown at a fairly steady rate, but slower than real GNP.

\- - -

The U.S. refining industry is in a period of profound change. For over 15 years the industry was protected from lower-cost foreign competition by an import quota system. But industry capacity grew at a slower rate than did product demand. Price controls were imposed during August, 1971, and they are still in effect.

World crude oil prices have recently been forced up to about 3 or 4 times their previous levels by the cartel of producing countries. They now are greater than the average of U.S. prices. Despite these high prices, oil product and crude oil imports have increased because domestic production has failed to keep pace with consumption. Recently the Federal government imposed a set of tariffs (fees) on imported crude oil and products that would, under normal conditions, provide a strong stimulus to the construction of new refineries in the U.S. But uncertainties about energy policies appear to inhibit the construction of new refineries. Some expansion of existing plants is taking place.

Compared to the above-discussed major changes in the economic environment within which the industry operates, pollution abatement costs will be small. So the impact on the refining industry of pollution abatement requirements will also be small.

SECTION I

DEMAND

A. The Products

The industry manufactures hundreds of distinguishably different products. From the viewpoint of environmental control costs these may be grouped into four broad product classes: gasoline, intermediates, residual, and other.

Gasoline accounts for about 45 percent of industry output. It is currently priced at about 30 cents per gallon[1)] in cargo lots on the Gulf Coast. Although other materials can be used as gasoline substitutes (propane, methyl and ethyl alcohol, electric batteries) their use is negligible for cost reasons.

Intermediates include military and commercial jet fuel, kerosene, space heating oil, also called No. 2 fuel or furnace oil, and diesel fuel. These products are currently also priced at about 30 cents per gallon and make up about 33 percent of industry output. No substitutes exist for the transportation fuel portion of the intermediates market. Natural gas is used extensively in the space heating market and may be more or less expensive than oil, depending on user location. Some heating oil is imported, which reduces the demand for domestic product.

Residual is currently priced at from about 25 cents to about 32 cents per gallon or even more, depending on sulfur content and location. Residual amounts to about 6 percent of domestic petroleum production and 17 percent of domestic demand for oils. The difference is accounted for by imports. Through most of the 1960's residual was priced sufficiently below crude oil to prompt increased investment in refineries in order to reduce residual yields. Under the current import fee structure residual oil is treated as any other refined product. Consequently the incentive to reduce residual yields exists only to the extent that this product competes with energy forms not produced from crude oil. In large volume installations natural gas and coal compete directly with residual oil.

1) Platt's Oilgram 12/6/74.

Other products include asphalt, lubricants, liquefied petroleum gas (mostly propane), naphthas and solvents, coke, petrochemicals and petrochemical feedstocks. (Asphalt and lubricating oils are important products for many small refineries.) These products account for about 16 percent of the domestic industry's output. They are priced from 15 cents to $1.00 or even more per gallon. Most lubricants and liquefied petroleum gas (LPG) have no significant economical substitutes from outside the industry. On the other hand, petroleum solvents face direct competition from the chemical industry. Non-metallurgical petroleum coke is exported in significant amounts. The market for this product depends in part on emission rules in customer countries.

B. Market and Distribution

The U.S. petroleum market has traditionally been divided into five geographic regions called "PAD Districts." (See Exhibit 1). Product consumption is also classified by end use.

Market data for 1969 through 1973 by product and District are shown in Exhibits 2, 2a, and 2b.

Oil products are distributed from refineries primarily by pipeline and tankers or barges to terminals. From there, local deliveries are made by truck. Some rail distribution is utilized. The impact of new environmental standards on the distribution and marketing of oil products does not fall within the scope of this study. But the costs of meeting new standards in moving the product from the refinery to the final consumer and in the associated storage facilities may be important. Environmental standards applicable to exploration and production of crude oil and natural gas also impose costs on the industry. The impacts of these costs are not a part of this study.

From the viewpoint of dollar volume, gasoline accounts for 50 percent of the refining industry's value of output. Intermediates

Exhibit 1

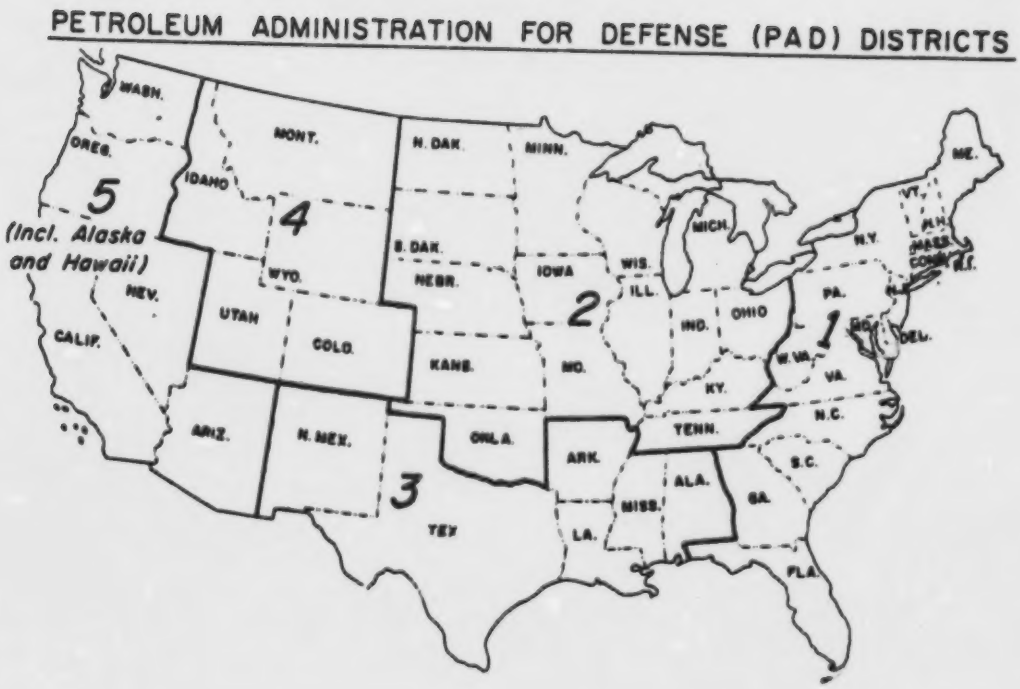
PETROLEUM ADMINISTRATION FOR DEFENSE (PAD) DISTRICTS
WASH.
OREG.
5
(Incl. Alaska and Hawaii)
CALIF.
NEV.
IDAHO
MONT.
4
WYO.
UTAH
COLO.
ARIZ.
N. MEX.
N. DAK.
MINN.
S. DAK.
NEBR.
KANS.
OKLA.
TEX
3
IOWA
MO.
ARK.
LA.
WIS.
ILL.
MICH.
IND.
OHIO
KY.
TENN.
MISS.
ALA.
GA.
FLA.
2
N.Y.
ME.
VT.
N.H.
MASS.
CONN.
R.I.
PA.
N.J.
MD.
DEL.
W. VA.
VA.
N.C.
S.C.
1

Exhibit 2

DOMESTIC DEMAND FOR PETROLEUM PRODUCTS
Thousand Barrels Per Day

Product	Year	P.A.D. DISTRICT I	II	III	IV	V	U.S.
Automotive Gasoline	1969	1,904	1,930	705	170	817	5,526
	1970	2,000	2,008	729	186	861	5,784
	1971	2,041	2,080	825	199	869	6,014
	1972	2,161	2,206	884	188	937	6,376
	1973	2,221	2,311	966	204	971	6,673
Jet Fuel Naphtha Type	1969	80	46	59	8	104	297
	1970	66	43	37	7	94	247
	1971	77	49	40	6	88	260
	1972	64	45	40	7	86	242
	1973	62	36	46	8	65	217
Jet Fuel Kerosene Type	1969	265	145	50	19	215	694
	1970	284	150	50	20	212	716
	1971	303	158	48	19	223	751
	1972	332	167	50	19	235	803
	1973	349	169	53	23	239	833
Kerosene (Ex Jet)	1969	144	83	39	6	3	275
	1970	126	83	43	6	5	263
	1971	130	77	32	5	5	249
	1972	119	67	38	6	4	234
	1973	90	64	53	5	4	216
Distillate Fuel Oil	1969	1,272	715	176	72	231	2,466
	1970	1,308	738	191	71	232	2,540
	1971	1,326	783	206	82	264	2,661
	1972	1,396	883	278	84	272	2,913
	1973	1,426	910	339	95	310	3,080
Residual Fuel Oil	1969	1,412	173	78	35	281	1,979
	1970	1,643	190	87	25	257	2,202
	1971	1,715	181	76	26	297	2,295
	1972	1,876	219	87	26	321	2,529
	1973	1,918	236	193	26	421	2,794

Source: Bureau of Mines, Mineral Industry Survey - Petroleum

Exhibit 2a

U. S. SALES OF DISTILLATE FUEL OIL, BY USES 1969 - 1973
(Thousands of Barrels)

Year	Vessels	Electric Utility Company	Railroads	Oil Company Fuel	Industrial	Diesel Engine Fuel (Excl. Railroads)
1973	26,645	78,110	102,930	14,965	67,166	273,385
1972	21,900	68,255	96,725	13,505	60,225	238,710
1971	20,959	35,329	86,251	14,088	49,558	213,906
1970	19,503	24,770	88,416	11,518	43,668	194,919
1969	18,877	12,158	86,429	13,867	42,456	188,253

				Total Domestic Sales	
	Heating	Military	Miscel-laneous	Excluding Fuel for Oil Company Use	All Uses
1973	535,820	19,710	5,475	1,109,235	1,124,200
1972	541,660	20,075	2,190	1,049,740	1,063,245
1971	523,648	17,427	10,154	957,232	971,320
1970	521,135	12,447	10,874	915,732	927,250
1969	511,768	13,958	12,534	886,433	900,300

Source: Bureau of Mines, Mineral Industry Surveys, "Sales of Fuel Oil and Kerosine," Annual.

Exhibit 2b

U. S. SALES OF RESIDUAL FUEL OIL, BY USES, 1968 - 1973
(Thousands of Barrels)

Year	Vessels	Electric Utility Company	Railroads	Oil Company Fuel	Industrial
1973	91,980	509,540	1,095	50,735	150,380
1972	77,745	434,350	1,095	44,165	141,985
1971	78,727	371,820	1,262	32,626	135,647
1970	89,850	312,420	2,222	38,318	139,647
1969	83,481	247,634	3,381	36,559	133,754
1968	87,575	184,956	4,296	39,329	135,664

				Total Domestic Sales	
	Heating	Military	Miscel-laneous	Excluding Fuel for Oil Company Use	All Uses
1973	187,975	19,345	9,125	969,440	1,020,175
1972	190,530	24,455	8,760	878,920	923,085
1971	182,639	29,217	6,109	805,243	837,869
1970	185,831	28,704	7,295	765,969	804,287
1969	178,095	31,750	7,875	685,970	722,529
1968	174,326	34,990	8,348	630,155	669,484

Source: Bureau of Mines, Mineral Industry Surveys, "Sales of Fuel Oil and Kerosine," Annual.

account for 31 percent and residual for only 4 percent.[1] Well over one-half of total refinery output is sold through distribution and marketing facilities which refining companies own or in which they have a financial interest. In general, sales of high-unit-value products (lubricants, gasoline, jet fuel) are more highly integrated than those of low-unit-value products. Most large companies operate their refining, distribution and marketing functions in an integrated manner. Assigning product prices at various points within the operation is an internal matter to most companies. Nevertheless, considerable product is sold by refiners directly to customers at published prices. Thus, conclusions adequate for this study can be drawn about the costs associated with new environmental standards.

Prior to the oil embargo of 1973/74, oil product prices had increased at a slower rate than either consumer or wholesale price indices, largely because the industry has been able to utilize improved technology to offset cost increases. In the absence of price controls, important short-term price changes do occur, mostly associated with changes in refinery utilization and with seasonal factors. Also, since crude oil accounts for over two-thirds of the cost of oil products at the refinery gate, product prices change with the price of crude. In recent years, product price changes have been largely the result of crude oil cost increases.

C. Government Influence on Market

Federal, state and local governments all influence the oil product market. The Federal Government's main current influence is through its price controls and tariffs on imports of crude oil and products. Price controls hold prices down and

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1) Because of residual imports, the relative contribution of the various products to domestic refiners' gross dollar revenue is different than the relative contribution at the consumer level.

discourage investment. But tariffs will drive prices up and encourage investment in new domestic refining facilities. It is not now clear which program will remain in force for the next decade. From 1957 to April 1973 importation of crude oil was limited by a quota system and product imports were essentially forbidden, except residual fuel oil. Foreign crude prices have until very recently been lower than domestic so import rights normally have had considerable value. These rights were allocated among refining firms according to their size. Although large firms had bigger quotas than small ones, the latter were given more "tickets" per unit of throughput. Currently imports are not quantitatively limited but some import limitations are again being considered.

All levels of government purchase large quantities and a wide range of oil products. One of these purchases, military grade jet fuel (JP-4), is important to some small refiners. A gasoline-like material, JP-4 requires little processing beyond separation from crude. In contrast, automotive gasoline is produced in a complex processing scheme.

Government also influences the market for petroleum products through imposition of environmental standards. This can take the form of direct specification of product characteristics, e.g., sulfur content in residual oil. Or it may take the form of imposing environmental standards on petroleum product users which in turn affect the nature of the product. For example, control of auto emissions has resulted in a demand for unleaded gasoline. In either case, the potential costs of changes in product characteristics far exceed the cost of bringing refinery operations up to environmental standards.

Government policy in pricing and regulation of natural gas, an important refinery fuel, also affects refining costs.

SECTION II

SUPPLY

A. Industry Operations

1. The production process.

Although a typical oil refinery is technically complex, the manufacturing process is conceptually simple.

Crude oil is the primary raw material used in refining. Crude oils are liquid mixtures of many carbon-containing chemical compounds. Crudes differ from one another in the relative concentration of the various compounds. In refining, crude oil is first separated into several groups of varying molecular size known as cuts. The chemical composition of some of these cuts is then altered by changing the average molecular size. Some cuts are further processed to alter the shape or structure of the molecules. Most of the original and the altered cuts are "treated" to make innocuous or to remove impurities, notably sulfur. Treated cuts are then blended to produce finished products. To these may be added various substances, known as additives, to impart certain desirable properties. Exhibit 3 classifies various refinery processes according to their principal function in the refining of petroleum: separation, alteration of molecules by size or shape, or treating. A schematic flow diagram of a refinery is shown in Exhibit 4.

In refinery operation certain polluting materials may be released into the environment. The pollutants are by-products of the various refinery processes.

The principal ones arise in operations as follows:

a. Hydrogen sulfide (H_2S) is present in many crude oils and is formed in hydroprocessing (catalytic reforming, hydrotreating and hydrocracking) and cracking (catalytic and thermal, including coking). Only trivial amounts, which can be ignored, are formed in other processes. Because H_2S is highly poisonous, it is either recovered (and converted to elemental sulfur)

Exhibit 3

FUNCTIONAL CHARACTERIZATION OF PETROLEUM REFINERY PROCESSES

A. HYDROCARBON REFINING PROCESSES

MOLECULAR CHARACTERISTIC ACTED UPON	Principal Process Purpose: Separation	Principal Process Purpose: Alteration (Conversion)
SIZE (Mole Weight)	Distillation (atmospheric and vacuum crude fractionation, naphtha splitting, depropanizing, debutanizing, vacuum flashing)	Thermal Cracking (visbreaking, coking)
	Absorption (recovery of ethane- or propane-and-heavier from saturated or cracked gas)	Catalytic Cracking
	Extraction (deasphalting)	Hydrocracking
		Alkylation
		Polymerization
SHAPE (Mole Structure)	Extraction (solvent extraction for separating aromatics from naphtha, lube oil, etc.)	Catalytic Reforming
	Crystallization (dewaxing of lube oil)	Isomerization

B. TREATING PROCESSES

Hydrotreating

Caustic Treating (Merox, Bender, etc.)

Clay Treating

Acid Treating

SCHEMATIC FLOW DIAGRAM OF PETROLEUM REFINERY

A. PETROLEUM PRODUCT MANUFACTURING

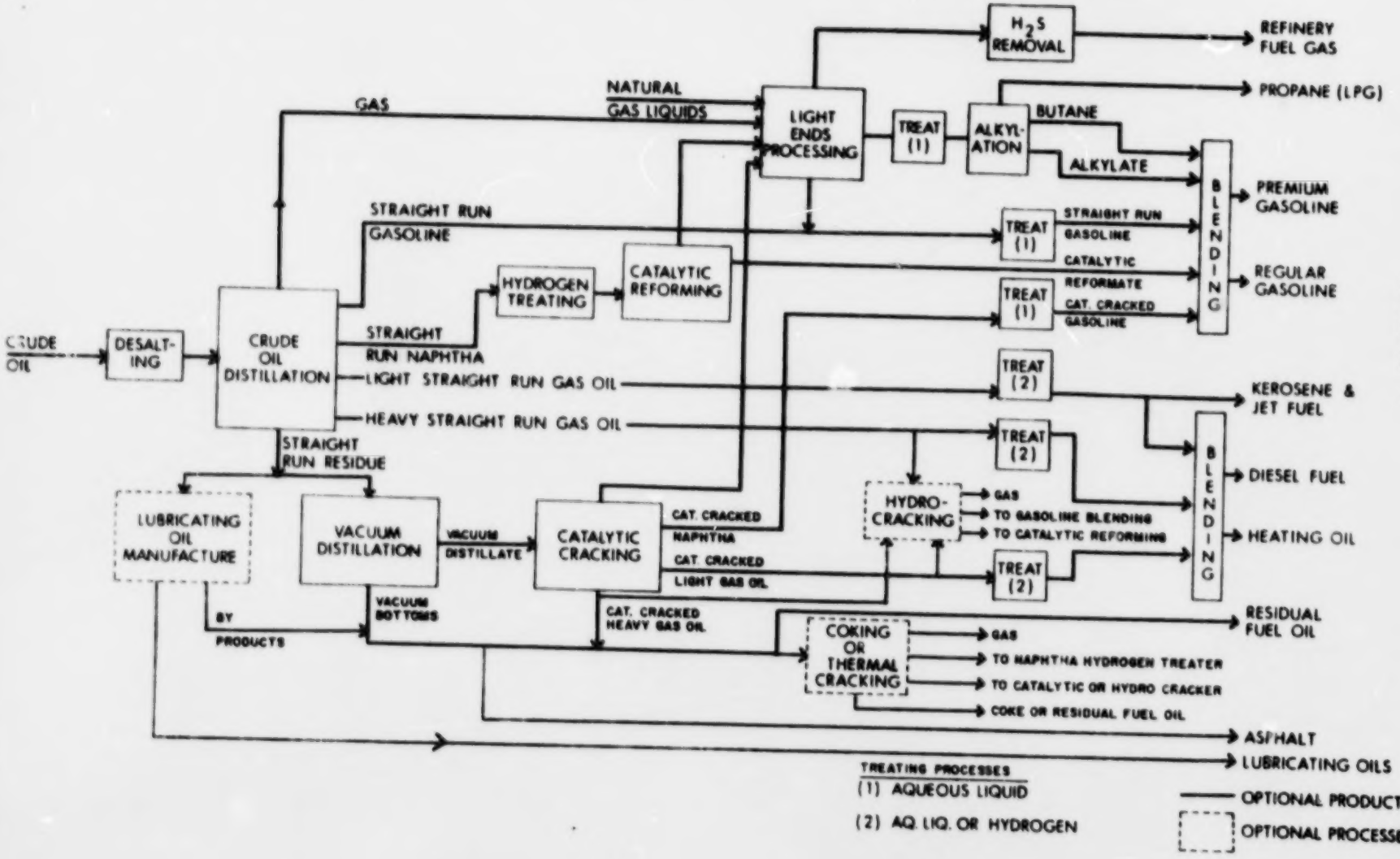

Exhibit 4

or burned. Burning forms sulfur oxides which are air pollutants.

Sulfur oxides are also formed in the combustion of sulfur-containing liquids. (Also, when liquid fuels containing nitrogen compounds are burned, the resultant nitrogen oxides may cause an opaque stack "plume.")

b. Hydrocarbon vapors can escape from tanks containing gasoline or crude oil.

c. Carbon monoxide (CO) is a by-product of catalytic cracking. Also some catalyst dust occurs.

d. Substances which create a biological oxygen demand (BOD) in waste water are formed in catalytic and thermal cracking, and in sulfuric acid treatment of petroleum products (notably naphthenic and Pennsylvania lubricating oils). Also most of the solvents (phenol, furfural, etc.) used in manufacturing solvent-refined lubricating oils create BOD.

e. Waste water from every refinery may contain oil or the water may not have a neutral pH.

Processes used to control the emission of these pollutants are shown in Exhibit 5. The schematic flow diagram in Exhibit 6 shows the collection and treatment of pollutants produced in each process.

EPA has assumed certain technological devices to be necessary and sufficient to meet proposed new environmental standards. They are:

1) Hydrogen sulfide removal from refinery fuel gas and conversion to elemental sulfur in plants equipped with tail-gas scrubbing. The entire sulfur control system is to be paralleled with a redundant facility.

Exhibit 5

REFINERY ENVIRONMENTAL CONTROL PROCESSES

Environmental Problem	Control Process(es)
Hydrogen sulfide. Reacts to form sulfur oxides if burned.	1. Gases containing hydrogen sulfide (H_2S) are treated with a liquid (usually an amine solution) which preferentially absorbs H_2S. The H_2S is recovered by stripping it from the liquid. It is subsequently converted to sulfur and recovered. 2. Sour water stripping. Aqueous effluents from refinery processes which contain H_2S are steam stripped to remove the H_2S.
Sulfur oxides. Emitted to the atmosphere with flue gases from burning fuels containing sulfur. Irritating to eyes and respiratory system. Also cause opaque "plume."	1. Hydrodesulfurization. The sulfur-containing oil is reacted with hydrogen at elevated temperatures and pressures in the presence of a solid catalyst. Sulfur is converted to H_2S. [Hydrogen for the hydrodesulfurization process is generally recovered as a by-product of catalytic reforming or manufactured by converting either natural gas or refinery by-product gases].

Exhibit 5 (Cont'd)

Environmental Problem	Control Process(es)
	2. Stack Gas Scrubbing. The sulfur-oxide-containing combustion gas is contacted with a solid or liquid material that preferentially absorbs the sulfur oxides. Sulfur oxides are then generally recovered in concentrated form from the absorbing material and converted to sulfur or sulfuric acid.
Carbon monoxide. Present in stack gas from catalytic cracking units. Poisonous to animal life.	1. Combustion. The stack gas is enriched with fuel gas and burned. Useful heat is recovered and the carbon monoxide is burned to harmless carbon dioxide.
Smoke. Produced when insufficient air is used in firing boilers and furnaces or by incomplete incineration of process materials vented and flared because of upsets.	1. Proper control of boilers and furnaces. 2. Incinerate vented materials in a "smokeless flare."
Soot and fly ash. Entrained in stack gas from furnaces or boilers fired with residual, coal or coke.	1. Electrical precipitation.
Hydrocarbon vapors. Evaporated from tanks or small leaks and spills. React in atmosphere to cause smog.	1. Install floating roofs or vapor recovery system on tanks. 2. Good housekeeping practices - fix leaks, maintain pump seals, clean up spills, etc.

Environmental Problem	Control Process(es)
Oil (and water-insoluble non-hydrocarbon liquid organic compounds) entrained in refinery waste water. Harmful to aquatic life and dirty.	1. API Separator. Oil is allowed to rise to the surface of the contaminated water and is skimmed off. 2. Aeration. Air is blown through the contaminated water. Oil rises to the surface as froth and is skimmed off.
Water-soluble organic compounds. Dissolved in refinery waste water. Many compounds toxic to aquatic life. Also reduce oxygen content of receiving water body which leads to aquatic life damage. May also smell badly.	1. Biological treatment. a) Trickle filter. Contaminated water is trickled through a pile of rocks on which live colonies of bacteria. The bacteria convert the contaminants into harmless compounds (mostly water and carbon dioxide). b) Activated sludge treater. Contaminated water is contacted with a suspension of bacterial colonies, nutrients and air. The bacteria convert the contaminants into harmless compounds. Clean water is separated by settling of bacterial sludge.
Phenolic compounds. Produced in cracking processes and extracted from cracked products. Toxic to aquatic life.	1. Sold to Chemical industry. 2. Incinerated. 3. Barred to sea and dumped. 4. Pumped into underground formation which is sealed to prevent contaminating fresh water. 5. Hydrotreat the cracked product to eliminate the need to extract phenols.

Exhibit 5 (Cont'd)

Environmental Problem	Control Process(es)
Fluid catalyst. Entrained in stack gas from catalytic cracking units.	1. Centrifugal separation. The stack gas is passed through a stationary centrifugal device (cyclone) at high speed. The resultant force throws the dust to the outside wall from which it is collected. 2. Electrical precipitation. The stack gas is passed between metal plates which are electrically charged to a high voltage. The dust is attracted to, and settles on, the plates from which it is recovered.

SCHEMATIC FLOW DIAGRAM OF PETROLEUM REFINERY

B. POLLUTANT COLLECTION AND TREATMENT

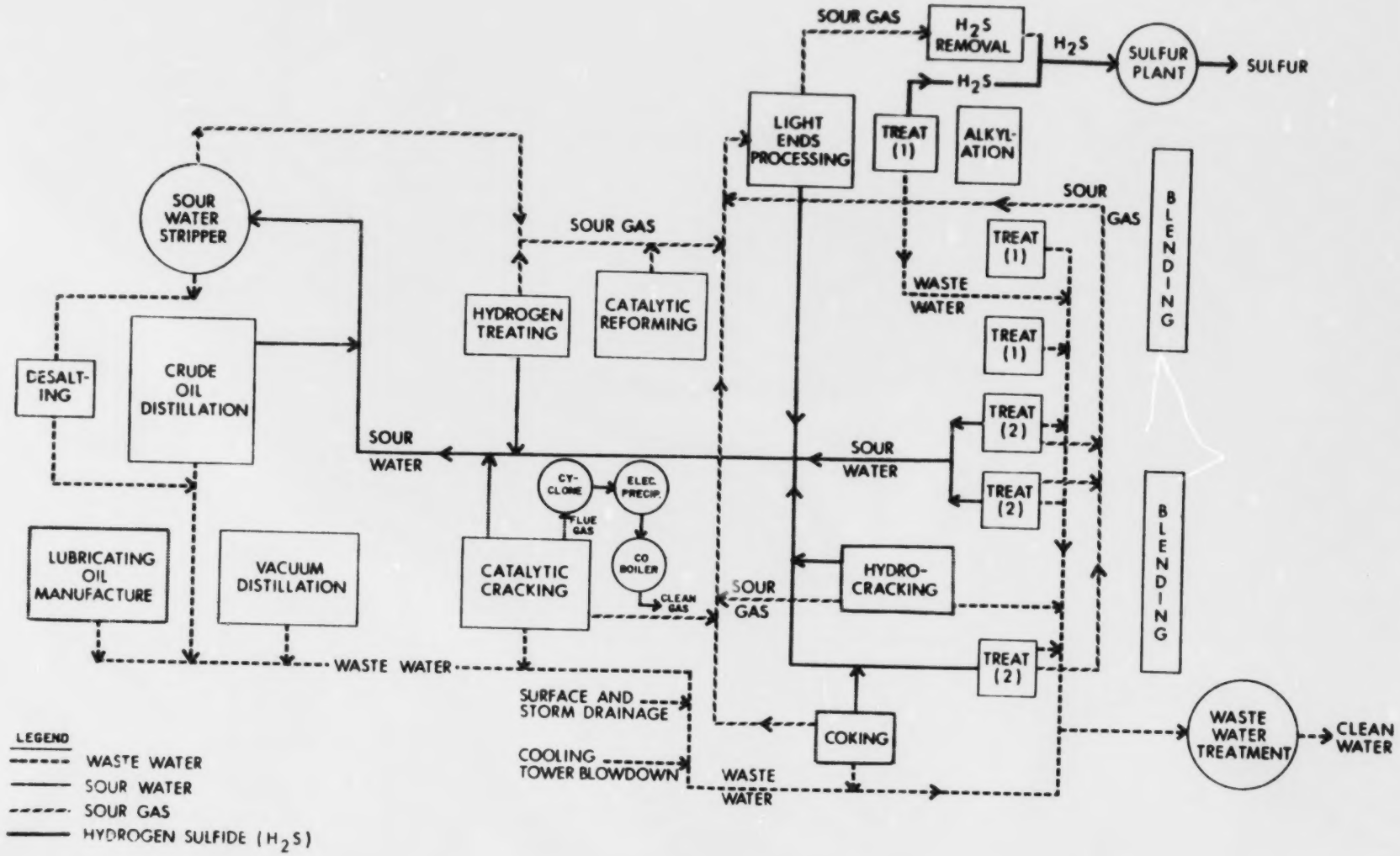

Exhibit 6

2) Floating roofs on gasoline and volatile crude oil storage tanks with more than 40,000 gallon capacity.

3) Catalyst removal from catalytic cracker regenerator flue gas by electrical precipitation and incineration of the flue gas in carbon monoxide boilers. An important EPA assumption was that both particulate and carbon monoxide emissions from catalytic crackers with fresh feed capacity below 10,000 barrels per stream day were so low that no equipment would be needed in these units.

4) BOD removal in an effluent treatment plant including equipment for water flow equalization, oil separation, neutralization, flotation, sedimentation, coagulation and biological treatment.

5) Oil and suspended solids removal and neutralization in a water-effluent treating plant simpler than that needed for BOD removal.

The foregoing classification can be summarized as follows:

Refining Processes Installed				Effluent Control Required		
				Air		Water
Large Cat. Cracker	Thermal or Small Cat. Cracker	Hydro Processes	Lube Mfg.	H_2S	CO & Cat.	BOD
x				x	x	x
	x			x		x
		x		x		
			x			x

The imposition of environmental controls on the quality of refinery products adds additional processing complexity to refineries. For example, much more catalytic reforming, as well as some other processes, will be introduced to make unleaded gasoline. Intermediates will require hydro-desulfurization. The manufacture of low-sulfur residual will require installation of considerable equipment. At the moment, the low-sulfur residual picture is complicated by wide variations in crude oil composition and varying sulfur content restrictions. Residual desulfurization is expected to be expensive. These matters are of compelling economic importance to many refiners.

2. Type and location of raw materials.

Crude oil is the most important raw material used by the refining industry. Natural gasoline, a liquid product of the natural gas industry, furnishes about 5 percent of refinery intakes. There are no other significant raw materials. About 73 percent of industry raw material is of domestic origin; 27 percent is imported.[1)] The imports originate in Canada, South America (largely Venezuela), Africa, Indonesia and the Middle East. It appears likely that the U.S. will in years to come import an increasing fraction of its crude oil requirements. Because Canada has plans for eliminating exports to the U.S. and Venezuelan production appears to have topped out, an increasing fraction of imports is likely to come from the Middle East.

The major crude-producing states are Texas, Louisiana, California, Oklahoma, Wyoming and New Mexico, although 30 of the 50 states have some production. Texas and Louisiana together account for about two-thirds of the domestic industry's crude oil production. Large Alaskan deposits will be

1) U.S. Bureau of Mines, Mineral Industries Surveys - Crude Petroleum August 1974.

exploited when a transportation system for them is built.

3. Number and location of firms and of plants.

There are about 130 firms in the oil refining industry. They own some 240 refineries located in 39 states. Refinery locations are concentrated along the Mississippi-Louisiana-Texas Gulf Coast, near Los Angeles and San Francisco, in the Pacific Northwest, near Chicago, near Philadelphia and in New Jersey, in Ohio, and in Oklahoma.

4. Types of firms.

Firms in the oil refining industry can be classified according to size, extent of integration, and the number and size of refineries owned. All refineries are necessarily multi-product and all perform the entire process of converting crude oil into salable products. All large and medium size firms, and some small ones, have diversified into chemical manufacturing. A very few have further diversified into other industries but the fraction of total capital employed in non-oil or chemical activities generally is small.

5. Types of plants.

Oil refineries are categorized by size and by the range of their products. There is also considerable variation in age of refineries. But classification by age is not useful because additions to and modifications of plants are the industry's principal form of expansion.

Exhibit 7 shows the distribution of refineries by size as of 1973. Refineries of over 100,000 barrels per day capacity account for 58 percent of U.S. refinery capacity (a barrel is 42 U.S. gallons). They number 41 out of a total of about 245 plants. Very few new refineries have

Exhibit 7

REFINERIES

DISTRIBUTION BY SIZE

1973

Refinery Capacity MB/CD*	Refineries			Capacity		
	Number	Percent of Total	Cum. %	MB/CD*	Percent of Total	Cum. %
Below 4	30	12	-	63	.5	-
4 to 6.9	35	15	27	183	1.4	1.9
7 to 14.9	28	11	38	287	2.1	4.0
Median (26)	(30)	-	50	-	-	(8.3)
15 to 29.9	44	18	56	978	7.3	11.3
30 to 49.9	27	11	67	1117	8.3	19.6
50 to 69.9	19	8	75	1116	8.3	27.9
70 to 99.9	21	8	83	1826	13.6	41.5
100 to 199.9	25	10	93	3291	24.5	66.0
200 and up	16	7	100	4570	34.0	100.0
Total	245	100%	100%	13431	100%	100%
Mean	-	-	-	55	-	-

* Thousands of barrels per calendar day.

Source: Oil and Gas Journal, 4/2/73, p. 102.
Data as of 1/1/73 - with minor adjustments

been built in the last seven years and few have been abandoned. Of a total population of about 260 seven years ago, 41 plants appear to have been shut down and 25 new ones built. Exhibits 8 and 9 show the distribution of refineries by size in 1971 and 1966. Those newly built plants which appear to be fairly complete refineries vary in size from 10,000 to about 150,000 barrels per day of throughput. It appears that size is not a characteristic which in itself accounts for turnover.

Multiple plant operations are commonplace in the industry. As of 1973, the 16 largest firms, each of which has over 200,000 barrels per day of total capacity, operated 109 refineries. These 109 plants accounted for 78 percent of the industry's capacity. A few of these refineries have capacities of less than 26,000 barrels per day. Half of all industry refineries (123 plants) are smaller than 26,000 barrels per day. They account for only 8 percent of industry capacity. (Exhibit 7)

Technological progress in the past 20 years has induced construction of larger, lower-unit-cost process units. Consequently, there has been a trend toward larger plants. No new plants of over 200,000 barrels per day have been built. Rather, the industry's net growth in capacity has been the result of smaller plants' expansion to this very large size class. In the last several years, quite a few large new refinery projects were announced and subsequently cancelled. One large new plant of about 200,000 barrels per day capacity is now under construction and two or three smaller refineries have recently been built.

Exhibit 8

REFINERIES

DISTRIBUTION BY SIZE

1971

Refinery Capacity 000'/B/CD*	REFINERIES Number	Per Cent of Total	Cum. %	CAPACITY 000's B/CD*	Per Cent of Total	Cum. %
Below 4	38	15	--	82	.6	--
4 to 6.9	35	14	29	187	1.5	2.1
7 to 14.9	37	12	41	329	2.6	4.7
MEDIAN 25	--	--	50	--	--	8.1
15 to 29.9	40	16	57	909	7.2	11.9
30 to 49.9	32	13	70	1306	10.4	22.3
50 to 69.9	17	7	77	970	7.7	30.0
70 to 99.9	22	9	86	1854	14.7	44.7
100 to 199	22	9	95	2940	23.3	68.0
200 and up	14	5	100	4028	32.0	100.0
TOTAL	251	100%	100%	12605	100%	100%
MEAN	--	--	--	50	--	--

*Thousands of barrels per calendar day.

Source: Oil and Gas Journal, 3/22/71, pp. 98ff.
Data as of 1/1/71 - with minor adjustments.

Exhibit 9

REFINERIES

DISTRIBUTION BY SIZE

1966

Refinery Capacity 000'/B/CD*	REFINERIES Number	Per Cent of Total	Cum. %	CAPACITY 000's B/CD*	Per Cent of Total	Cum. %
Below 4	53	20	20	111	1.1	1.1
4 to 6.9	25	10	30	122	1.2	2.3
7 to 14.9	35	14	44	371	3.6	5.9
MEDIAN 20	--	--	50	--	--	8.7
15 to 29.9	46	17	61	1008	9.8	15.7
30 to 49.9	38	15	76	1512	14.8	30.5
50 to 69.9	15	6	82	860	8.4	38.9
70 to 99.9	20	8	90	1595	15.6	54.5
100 to 199	20	8	98	3018	29.4	83.9
200 and up	6	2	100	1650	16.1	100.0
TOTAL	258	100%	--	10247	100%	--
MEAN				40		

*Thousands of barrels per calendar day.

Source: Oil and Gas Journal, 3/28/66, pp. 154ff.
Data as of 1/1/66 - with minor adjustments

The trends in the industry most significant to this study are that the number of refineries has decreased slightly and their average size has increased.

In general, very small refineries with intakes below about 10,000 barrels per day have few units and manufacture only a narrow range of products. Some small refineries in Pennsylvania, southern Arkansas, Oklahoma, and south Texas take advantage of local crude quality to manufacture lubricants.

Asphalt is also an important product for many small refineries. It is costly to transport, especially overland. Therefore, a relatively large fraction of the industry's asphalt output is produced in small refineries and over a third of the plants with capacities below 10,000 barrels per day produce asphalt as a principal product.

As regards refinery differentiation by product slate, some small refineries are designed to process low-sulfur crude oil into the naturally occuring volumes of gasoline, intermediates and residual, or asphalt which is essentially a special grade of residual. Such a refinery requires only a crude oil distillation unit, a catalytic reformer with feed pretreater, two or three additional distillation columns and treating units. Some small refiners in southern California due to the characteristics of local crude oil manufacture military jet fuel and residual with only a crude oil unit. On the other hand, a large refinery manufacturing a full range of fuel products plus lubricants, industrial solvents, liquefied petroleum gas and a few common chemicals will have a score or more of process units.

A common technology is used throughout the industry. The differences that do exist are small and probably not significant in terms of a plant's ability to meet environmental standards economically. There are important differences in the extent to which environmental control equipment has been installed to date.

6. Employees.

Data on employment and earnings are presented in Exhibit 10. About 60 percent of petroleum refining employees are production workers. Their hourly and weekly earnings are considerably above the average for all manufacturing. Hourly earnings of production workers in 1973 in petroleum refining were estimated at $5.54 versus $4.07 for all manufacturing.

Refinery employment as a whole has been fairly stable. In 1964 there were 150,000 employees and 1972, 151,000. In the same period the industry's capacity rose about 20 percent mostly as a result of capacity increases in existing refineries. A great many refineries, about two-thirds of the total, have been expanded in the last 8 years. It is likely that the bulk of the net employment increases have taken place in very large refineries, those over 100 or even 200 thousand barrels per day of throughput which also account for almost the entire net growth in output.

Perhaps one-third of refining industry employees have skills which are not readily transferable to other industries. While it was clearly beyond the scope of this study to make an analysis of the transferability of the skills required by the industry, an examination of the occupational titles indicates that two-thirds of the employees have skills which are not special to the industry or they are unskilled.

Detailed occupational data for the petroleum refining industry are available for the year 1965. In that year, 148,000 people were employed in the petroleum refining industry, 89,000 of whom were production workers. These figures include employment in central offices, research laboratories, etc. of refining firms as well as in refineries.

Exhibit 10

EMPLOYMENT, EARNINGS AND PAYROLLS
IN PETROLEUM REFINING, 1964-1973

	Total Number of Employees[2] (Thousands)	Production and Related Workers[1]			
		Number of Workers (Thousands)	Average Weekly Earnings	Average Hours Worked Weekly	Average Hourly Earnings
1973	147	89	$231.02	41.7	$5.54
1972	151	89	219.45	41.8	5.25
1970	154	90	189.93	42.3	4.49
1968	151	92	166.27	42.2	3.94
1966	148	89	151.56	42.1	3.60
1964	150	90	139.52	41.4	3.37

1) Includes non-salaried workers.

2) Includes both salaried and non-salaried employees.

Source: Bureau of Labor Statistics, "Employment and Earnings." Reprinted in Petroleum Industry Statistics 1964/73, American Petroleum Institute, September 1974, p. 50.

Refinery employment was about 106,000 including about 77,000 production workers. A Bureau of Labor Statistics study[1)] of a representative sample of 46,000 of the 77,000 showed that almost one-third of refinery production workers were maintenance workers and 85 percent of these were skilled craftsmen, such as welders, mechanics, machinists, electricians, etc. One half of production workers were skilled refinery operators such as stillmen, treaters, compounders, testers, etc. These men's skills are probably transferable only to other similar industries, such as chemical manufacturing or food processing. The balance of the production workers are either unskilled, or are helpers, or have general skills such as stock clerks or truck drivers.

Thus it appears that about one-third of the people in the industry (probably a smaller fraction in small plants) are skilled workers whose job opportunities at a comparable skill level are dependent on re-employment in the "process" industries. The other two-thirds are employable in other industries at their present skill levels if job opportunities exist for them.

B. Financial Structure and Trends

It is impossible to analyze the financial structure of the petroleum refining industry using published data. Too few firms and none that are typical of the industry are exclusively or even primarily in the refining business. To discuss the financial characteristics of the industry we shall use price data which reasonably reflect the values of products made by typical refiners, and we shall assume cost data we consider appropriate for crude oil.

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1) Industry Wage Survey, Petroleum Refining, December 1965, Bulletin No. 1526, U.S. Department of Labor. Bureau of Labor Statistics, p.12.

Sales volume in the oil industry has risen almost without interruption and at a fairly steady rate for many years.

1. Costs - fixed and variable.

No data are published which break down refinery costs in a manner useable for this study. We have therefore made such an estimate for a plant manufacturing fuel products (no lubricants). We caution the reader that no actual refinery will exactly match these figures. Refining costs are characterized by a very high ratio of raw material costs to total cost. Fixed costs make up most of the balance. Our illustrative estimate of costs follows:

Costs - Fixed and Variable (1974 prices)

Item	Cost/Barrel of Refinery Intake	Percent of Total Costs	
		Fixed	Variable
Raw Materials (Average)	$ 8.00		75%
Fuel and Utilities	.90	2%	7%
Labor	.35	3%	
Chemicals, Catalysts, Additives & Materials	.35		3%
Insurance and Taxes	.10	1%	
Capital Charges[1)]	1.00	9%	
TOTAL	$10.70[2)]	15%	85%

2. Profits

No data on refinery profitability are available. But we can assume that in the absence of price controls or product allocations refining operations are, on the margin, neither more nor less profitable than the rest of a typical oil company's business. The effect of price controls on refining profitability cannot be ascertained. Exhibit 11

1) Basis 8-10 percent per year cost of capital.

2) Equivalent to about 27 cents per gallon of salable product. Current spot cargo prices are higher than this because marginal crude is imported at a cost greater than $8/barrel.

Exhibit 11

RATE OF RETURN ON NET WORTH FOR PETROLEUM, MANUFACTURING, AND ALL INDUSTRY IN THE U.S., 1964-1972

Year	Petroleum Industry	All Manufacturing Industry	All Industry
1972	10.8	12.1	10.5
1971	11.2	10.8	9.7
1970	11.0	10.1	9.0
1969	11.9	12.4	10.3
1968	13.1	13.3	10.8
1967	12.8	12.6	10.6
1966	12.6	14.2	11.3
1965	11.9	13.9	11.1
1964	11.5	12.6	10.3

Source: First National City Bank, "Monthly Economic Letter," May, 1973.

gives some relevant financial data for the oil industry. While profitability of the business as a whole has been subject to some variability, industry earnings have been adequate to attract capital to finance growth and replacement.

3. Cash flows.

It is impractical to make an estimate of the refining industry's capital requirements for expansion and plant modernization in the years to come. In 1973, the thirty largest petroleum companies invested about $1.3 billion in refineries and chemical plants[1)] in the U.S. If normal growth rates were to prevail then capital expenditures on these plants in the next 10 years would be about $15 to $20 billion. But energy conservation measures as well as the recent increases in crude oil prices may depress capital requirements while the desire to decrease dependence on foreign sources of products may increase them.

Substantial amounts of additional capital will be required for equipment to manufacture environmentally "clean" products. Capital requirements for this purpose are expected to be about $5 billion (EPA estimate). Finally, $2 billion will be needed to conform refinery operations to environmental standards.

It is useful to put our estimates of capital requirements for refineries in perspective with oil company capital expenditures for all purposes. Data on a group of 30 large oil companies show that roughly 17 percent (about $1.3 billion of $7.6 billion) of domestic capital expenditures by this group represents investment in refineries and chemical plants

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1) The Chase Manhattan Bank, N.A., Financial Analysis of a Group of Petroleum Companies, 1973, p.29.

in 1973.[1] Total domestic investment in that year for the same group of companies is about 52 percent of world-wide investment.[2]

C. Refinery Technology and Technological Trends

Petroleum refining has been a high-technology industry since World War I. The technology of the industry has steadily improved. A few major breakthroughs, notably thermal and catalytic cracking, catalytic reforming, and solvent extraction of lubricating oils have had profound effects. But of almost equal importance in the long run has been the improvement in existing processes. Technological improvements are utilized industry-wide because industry members traditionally license the use of significant new technology to competitors. There are no important trade secrets in the refining industry.

A combination of product quality competition and economies of building and operating larger plants has served to push oil refining firms toward bigger and more complex refineries. Product quality competition has been achieved by the use of additives and of quality-improving processes like catalytic reforming to increase gasoline octane number, and by catalytic hydrogen treatment to reduce sulfur content of intermediates. This has led to an increase in the amount and value of processing equipment per unit of output. Relatively low residual prices which have encouraged investment to reduce residual yields also raise the value of equipment per unit of output. Recent changes in import policies allow domestic residual oil to be priced competitively with other domestic products. Consequently, some recent refinery expansions and the one large new plant under construction no longer emphasize the minimization of residual yields.

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1) Ibid., p.29

2) Ibid., p.18.

Thus, larger refineries and larger units within existing refineries mark the industry's development. Once the capability exists to build and operate larger plants there is a strong economic incentive to do so. Large plants cost less to build per unit of intake than smaller ones. Typically, it only costs 60 percent more to build a plant with 100 percent more capacity (the "two-thirds power rule").

This does not mean that an existing small plant is necessarily unviable. Existing small plants are effective competitors. But typically new small plants are not being built, except for an occasional asphalt plant.

D. Industry Utilization Rates

U.S. refineries are currently processing crude oil at an average annual rate of about 90 percent of reported capacity. This is about the typical long-run figure for the industry of about 88 percent. The recently proposed "ticket" system under which refiners are allocated rights to purchase domestic price-controlled oil according to their total runs will tend to increase operating rates.

It is important to differentiate between a refinery's capacity to process crude oil and its capacity to manufacture a particular product. Almost all refineries have the flexibility to alter their product mix. They can to some extent increase the output of gasoline at the expense of intermediates or they can produce more intermediates at the expense of gasoline. Nearly all refineries could increase residual manufacture above the design level. Published data on capacity utilization cannot reflect the industry's ability to alter yields. Hence, they are not useful in estimating the industry's ability to increase output of specific products.

Requirements to manufacture products with specific properties further influence capacity. A refinery that can manufacture 100 volumes of 94 octane leaded gasoline might be able to make only 70 volumes of lead-free 94 octane with its current equipment.

Producing low-sulfur residual also presents special problems. In the U.S., residual is essentially a by-product of the refining process. Its sulfur content is predominantly dependent on the sulfur content of the crude the refinery uses. It follows that most refineries have no "capacity" to produce low-sulfur residual from their normal crude stream. Some desulfurizing capacity has recently been installed.

Availability of fuel of acceptable quality for internal refinery use also affects refinery capacity. Refiners normally burn in their internal operations the lowest valued material available. They first use the gases produced as a by-product of refining operations because these gases generally have no market. The next choice is purchased natural gas, if available, because it is priced below residual (per BTU) in most parts of the U.S. and the facilities needed to burn gas are cheaper than those needed to burn liquids. A small amount of coal is also used in Pennsylvania and West Virginia. The remaining requirement, about 135,000 barrels a day[1)] currently, is met largely with residual fuel. Residual and coal normally contain considerable sulfur. Thus, if low sulfur rules are imposed, some refinery capacity will depend on availability of low-sulfur residual.

Similarly, the availability of gas in some instances affects capacity. Refineries with no facilities for burning liquid or solid fuels would have to install new equipment if gas were not available in sufficient quantity. This would be expensive as well as time consuming.

E. Competition

Were it not for price controls, the market for wholesale oil products would be competitive in the economist's meaning of

1) Mineral Industry Surveys, op. cit., April 1974.

the term. That is, the price elasticity of demand facing individual firms would be high. Despite a strong and continuing industry effort to establish brand differentiation for retail consumers, the wholesale market operates on a commodity basis. Perhaps one-third of gasoline,[1] about 50 percent of intermediates and almost all residual are sold as commodities. With such large volumes sold by many refiners an active brokerage business exists. Non-branded marketers maintain aggressive purchasing staffs, and oil companies compete vigorously on various "bid" markets.

Prices on the various unbranded markets typically are close to short-run marginal costs. This indicates that the industry is highly competitive. The normal competitive nature of the refining industry would affect its ability to pass cost increases on to consumers in the short run. But with price controls and allocations normal market forces no longer determine prices, product distribution or profitability.

Prior to 1972, foreign crude oil was less expensive than domestic. Although the domestic price was protected by an import quota, production failed to keep pace with demand. In mid-1973, prices became equal due to the success of the oil cartel (Organization of Petroleum Exporting Countries). At the same time, U.S. refinery capacity became insufficient to meet the U.S. demand for light products (gasoline, heating oil, etc.). Price controls have been in effect on domestic products most of the time since 1971. A program was announced in 1972 to encourage domestic production and refining by imposition of a tariff system.

Prior to the oil embargo the industry was in transition from a quota system to a tariff system via a price control

1) So-called unbranded sales at retail by independent oil companies, commercial sales direct to users and sales to government aggregate to somewhat over 30 percent of total gasoline sales.

system. In the present situation, it is not clear how market conditions will develop. However, a significant disparity between world and average domestic prices as a result of domestic price control now exists. And the combination of a two-price (new and old crude oil) market with a system of entitlements to purchase "old," lower-priced, crude oil makes it impossible to generalize about market conditions.

PART II

ECONOMIC IMPACT ANALYSIS[1)]

1) This part of the report has been prepared by EPA.

EXECUTIVE SUMMARY

Overview

Although from the data available, there appears to be no definite indication that any significant economic impact will result from the imposition of the proposed guidelines for petroleum refineries, the conclusions depend heavily upon the assumed scenario of government involvement in the industry. The three most likely scenarios are:

1. Competition of U.S. crude oil and products in the world markets; or
2. U.S. market price-controlled at roughly the current prices of crude oil and products, with price increases permitted to recover increased costs; or
3. U.S. markets for crude oil and products uncontrolled, but protected by import "license fees" at world price plus 1/2 cent per gallon for crude oil, and world price plus 1-1/2 cents per gallon for products.

As a result of recent world developments, and partial domestic price control, there is a substantial differential between world and domestic prices of crude and products. And the profitability of most firms in the petroleum industry has risen considerably. But we have no data on the profitability of the refining segment of the industry since there are no public firms that are only in refining. In the long run, the likely severity of economic impact on small refineries will depend on the scenario that occurs.

Scenario #3 was the situation until the Arab oil embargo. Prior to the embargo, world prices were less than domestic prices, and the domestic market was protected by "license fees." Under this system, each domestic refinery could, by 1975, realize a cash flow of up to 42 cents per

barrel more than refiners outside the U.S. Thus, if pollution control costs, plus any other competitive cost disadvantages, were less than this "subsidy," one would anticipate no shut-downs of domestic refinery capacity.

Under the price-controlled scenario, pollution control costs, including capital charges, could be allowed to be passed on to the extent that price control regulations provide. But this could tend to create problems for many small refineries that would incur unit costs much greater than those of the large refineries. Depending upon the Federal Government's protective interest in maintaining refinery capacity and the extent of the actual refinery capacity shortage, small refineries would become solely dependent upon governmental policy to maintain their economic viability.

Under the license fee scenario (#3), it appeared to us that only 2 to 11 small refineries would be threatened by these guidelines by 1977. These refineries represent a negligible amount (0.02% - 0.3%) of total refinery capacity.

Prices

As shown in Table I, aggregate cumulative costs of water pollution abatement will be approximately 9.4 cents per barrel by 1977 and 14.4 cents per barrel by 1983. Many refineries will be induced to provide capital for in-plant alternatives for water conservation (about 3 cents of the total 9.4 cents per barrel by 1977). The ¢/barrel figures are averages, and, since prices in this industry are competitively determined by the marginal costs of the least efficient refiners (that are required to be in business in order that demand be met), these numbers may differ from actual price increases that are implemented. However, they do represent an aggregate average indication of unit cost pressures expected from water pollution abatement. Thus, one might expect price

TABLE I

WATER POLLUTION CONTROL COSTS

	Capital Investment Million $	Annual Costs Million $ Per Year	Annual Costs Cents Per Barrel
1977 - Existing Sources (Best Practicable Control Technology Currently Available)	1112	449	8.9
- New Sources (New Source Standards)	75	26	0.5
1983 - Additional for Existing Sources (Best Available Technology Economically Achievable)	625	250	5.0

Source: Roy F. Weston, Inc., Effluent Guidelines Development Document: Petroleum Refining, December 1973, p. 114.

increases of 9-10 cents per barrel (0.21-0.24¢/gal.) by 1977 and 14-15 cents per barrel (0.33-0.36¢/gal.) by 1983.

Profitability

There is tremendous variability of treatment costs per barrel of product for small refineries (less than 25,000 barrels per day capacity) as compared with the relative constancy of costs for larger refineries. Overall, the costs of flow reduction and end-of-pipe treatment range from approximately 2-65 cents per barrel for 1977 requirements, and about 8.5-80 cents per barrel for 1983. Since it is expected that these costs will be charged directly against refinery operating costs, wide ranges of profitability changes for the small refineries will be observed.

Production Effects

The above cost data were used to develop an estimate of potential impact. As previously mentioned, no more than 2 to 11 small refineries would incur pollution abatement costs that might force their closure by 1977. These "critical" refineries represent only 0.02%-0.3% of current refining capacity. No production curtailments are expected because a trivial increase in the rate of growth of new capacity could absorb any such lost capacity.

Employment Effects

From the above conclusion regarding production curtailments only a very small number of the refinery workforce appears to be in danger of job dislocation. If we assume industry average productivity per employee for these small refineries, approximately 100-500 out of the 150,000 refinery employees would be the maximum number to face job losses. Since these refineries are

located in several, generally rural, geographical areas, the community and regional impacts of even the highest estimate of job loss does not appear to be substantial. If, however, job dislocations occur, some local secondary impacts on retail and service establishments and on specific communities would also probably take place.

Effects on Industry Growth

Although the total $1.8 billion required expenditure through 1983 for water pollution control appears to be relatively large, it is not expected that this requirement will jeopardize the refining industry's capacity for expansion throughout the decade. Estimated capital expenditures for domestic refineries in 1973 were roughly $1 billion.[1)] Furthermore, the industry itself claims $288 million were spent in 1972 alone on water pollution abatement.[2)] Hence, achievement of the 1977 guidelines would require average capital expenditures of about $200 million per year during the period 1973-1977. The industry (overall) should find the capital markets responsive to its needs, particularly in the short run. Whether this is true in the long run for small refineries is dependent upon the protection afforded them as a part of domestic energy policies. The License Fee System, as set up in 1973 protected small refineries against foreign competition (but not against domestic competition). Such protection may be provided by either:

1. Price controls under which small and large firms are treated differently.

1) Financial Analysis of a Group of Petroleum Companies, 1973, The Chase Manhattan Bank, N.A.

2) Environmental Expenditures of the United States Petroleum Industry 1966-1972. American Petroleum Institute Publication No. 4176.

2. The fee structure, set up so that the first "X" barrels/day for a small refiner are exempted from the fee.

3. Preferential access to either domestic or foreign crude oil supplies, whichever is cheaper.

Balance of Trade

Due to the magnitude of the difference between world and domestic prices, and the unlikelihood that scenario #1 (on page II-1) will occur, no negative balance of trade effects attributable to the effluent guidelines are expected.

INTRODUCTION AND METHODOLOGY

The purpose of this study, as well as other micro-economic impact studies of water pollution control, has been to develop estimates of the impact of control requirements on prices, profits, plant closings, employment, community development and the balance of trade.

The analysis of the economic impact of the proposed effluent limitation guidelines on the petroleum refining industry involved four basic steps:

1. Estimation of the incremental cost of pollution control to be incurred by various types and sizes of refineries for installing end-of-pipe treatment.
2. Estimation of the cost of water conservation for profligate water-users.
3. Assessment of the climate for price increases by the industry, analyzing the most likely scenario regarding government influences on the economic dynamics of the industry.
4. Assessment of the impact of the calculated water pollution costs in terms of plant closures, or decreases in profitability.

End-of-Pipe Treatment Costs

The costs of treating refinery waste water to the Best Practicable Control Technology Currently Available and Best Available Technology Economically Achievable requirements were developed for EPA by a technical contractor.[1] These costs were then

1) Roy F. Weston, Inc., Effluent Limitation Guidelines Development Document - Petroleum Refining

adjusted from 1971 construction costs to 1973 construction costs, and from an after-tax cost of capital of about 16% to a more reasonable 12%. It was found that the resulting costs depended essentially solely on waste water flow rate.[1] There is a slight effect of contaminant load (represented by "refinery category" as defined by the technical contractor), but it is negligible compared to the flow effect. Total industry end-of-pipe investment cost for BPT and BAT are estimated at $712 million and $625 million, respectively.

The economics of scale in waste water treating are evident from the following table:

Cost to Achieve Best Available Technology Standards with End-of-Pipe Treatment

Flow Rate, million gallons per day	Cost of Treatment	
	$ million per year	$ per thousand gallons
0.01	0.20	56
0.1	0.50	14
1.0	1.5	4
10.0	6.8	2

The table also shows the large incentive for reducing waste water flow volume.

1) The costs are adequately represented by intersecting straight lines on log-log graph paper through the following plot points:

BPCT: 0.025 million gallons per day/$0.14 million per year
0.50 million gallons per day/$0.44 million per year
10.0 million gallons per day/$3.9 million per year

BAT: 0.025 million gallons per day/$0.29 million per year
0.54 million gallons per day/$0.96 million per year
10.0 million gallons per day/$6.8 million per year

In-Plant Water-Use Reduction Costs

Normal refinery practice permits waste water flows of less than one-tenth of crude oil intake (4 gallons per bbl.)[1] But some plants discharge over 100 times as much.[2] If the cost of conserving water within the refinery is less than the cost of treating waste water, it will be advantageous for a plant to optimize the combination for minimum cost.

Almost no data was available on the cost of in-plant flow reduction. However, the following three data points have been developed through case examples:

Waste Water Flow Reduction Million Gallons Per Day	Cost, Million Investment	Annual[3]	Cost, $ Per Thousand Gallons
78	11	2.75	0.10
62	12	3.0	0.13
40	8	2.0	0.14

These unit costs are one to two orders of magnitude less than the unit waste water treating costs for end-of-pipe treatment. Hence, it will be much cheaper for profligate water users to install in-plant modifications plus smaller waste water treating facilities than to install large treating facilities.

It is unfortunate that the three data points represent fairly large refineries, because such plants will clearly be able to afford to install facilities to conform to environmental regulations. It is the smallest plants, those with crude

1) Roy F. Weston, Inc., op. cit.

2) Ibid.

3) Based on following assumed costs:

	% of Investment Cost
Amortization	12%
Operating, Maintenance and Energy	13%
Total	25%

processing capacity of less than about 10,000 barrels per day, that will be disproportionately affected. However, the most profligate water users in this size class discharge roughly 5 million gallons per day of waste water, which is only a tenth as large as the flows encompassed by the three data points.

The problem of establishing better waste water flow reduction cost estimates for small refineries remains to be adequately solved. In order to complete this study, the three data points were used as a basis for extrapolating small refinery costs. Two extrapolations[1)] were used, yielding costs of $3.1 and $1.2 per thousand gallons for reducing waste water flow by 0.1 million gallons per day. Such costs are only one-fifth to one-tenth as great as the end-of-pipe treating costs. It is obvious that it is important to establish reasonable estimates of the optimum costs for the combined in-plant and end-of-pipe facilities. EPA estimates that industry cost for in-plant modifications by 1977 will be about $400 million.

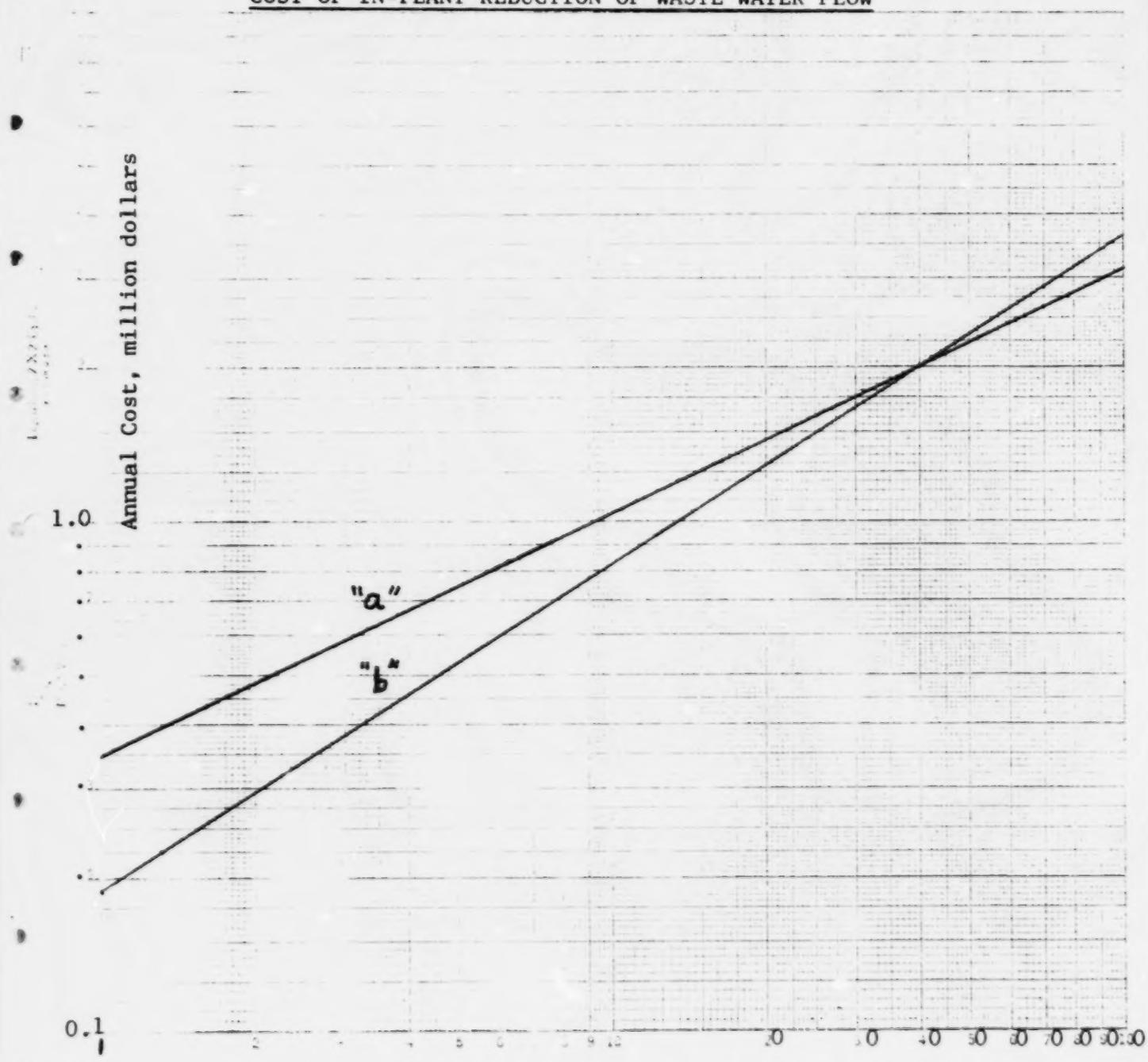
Combined Costs

Although the extrapolated costs in the preceding section cannot be supported as definitively as one would like, the analysis was completed recognizing this limitation. "Example" combined minimum costs of in-plant plus end-of-pipe modifications were computed for several combinations of refinery size, waste water discharge rate and extrapolated costs of in-plant modifications to reduce waste water flow. Results of these calculations appear in Table III.

1) Both are straight lines on log-log graph paper. (See Figure 1)
"a" goes through the points
78 million gallons per day/$2.75 million per year
40 million gallons per day/$2.0 million per year
"b" goes through the points
70 million gallons per day/$2.87 million per year
40 million gallons per day/$2.0 million per year

FIGURE 1

COST OF IN-PLANT REDUCTION OF WASTE WATER FLOW



If small refiners were fully cost competitive (except for the costs discussed here), then under the License Fee System about 42 cents per barrel would be the maximum that those refineries could absorb. In-plant cost extrapolation "a" says that a 2,000 barrel per day refinery with 500 gallons waste water per barrel is not viable (47¢ per barrel cost) whereas extrapolation "b" says that it should be viable (26¢ per barrel cost). Additional technical research on the costs of in-plant modifications would obviously be useful. However, our best current estimates for 1977 for end-of-pipe and in-plant modification costs for the industry are $712 million and about $400 million, respectively. The total is $1.112 billion.

Impact Analysis

From refinery size and waste water distribution data from the 1972 EPA/API Survey, critical size and water-use categories were determined based on the pollution abatement costs and coupled with the analysis of the projected economic position of the small refineries. As the impact analysis that follows suggests, no small refineries are projected to close in the short run due to water pollution abatement costs. The long run situation will depend on the scenario that occurs. Other factors more likely to be troublesome for the small refinery in the future may be the EPA low-lead/lead-free gasoline regulations.

I. PRICE EFFECTS

Due to price controls the pricing mechanism of this industry is currently in a state of flux. Also, as long as world prices remain well above domestic prices for crude and products, this price disparity may provide a cushion that eliminates severe economic impacts. Price increases as a result of water pollution abatement on the order of only 9 cents to 10 cents per barrel can be expected by 1977, and as long as price controls are effective on all firms these cost increases may be passed through.

The impact of pollution control costs was analyzed under the following three scenarios regarding Federal Government control over the petroleum markets.

1. Competition of U.S. crude oil and products in the world markets.
2. U.S. market price-controlled at roughly the current price of crude oil and products, with price increases permitted to recover increased costs of pollution control.
3. U.S. markets for crude oil and products protected by import license fees at world prices plus 1/2 cent per gallon for crude oil, and world price plus 1-1/2 cents per gallon for products.

The effects of these scenarios would be:

1. Under free market competition, world and domestic prices would be expected to draw closely together. At the limit (nearly equal price levels), domestic refineries, facing environmental control expenditures not faced by firms abroad would have a cost disadvantage. This could impact particularly heavily

on small (less than 10,000 b/d) refineries.

2. If price controls constrain refined product prices below world prices, there is potential capability for the government to allow pollution control costs to be passed through to consumers. A problem is that the small refineries would be forced to pass along greater (to them) unit costs than would the large companies. Hence, they might be limited (by the market) to charging a price insufficient to cover all their costs. Their ability to attract capital would then be impaired.

3. Scenario #3 is relevant only if world prices are roughly equal to (or less than) domestic prices. The fee system was designed to encourage new refinery expansion and construction within the United States. Basically, the fee system required a tariff on imported crude oil and refined products. This system allowed domestic product prices to increase up to the imported price of world petroleum products plus the tariff. The scheduling of the fee system was as follows:

	Fee (Cents/Barrel)		
Timing	Crude Oil	Resid., Distillates and Unfinished Oils	Gasoline
May '73	10.5	15	52
Oct. '73	13	20	54.5
May '74	15.5	30	57
Oct. '74	18	42	59.5
May '75	21	52	63
Oct. '75	21	63	63

Thus, if a refiner were to buy crude at world-plus-fee prices (after October 1975), and sell his products on the same basis, he would receive 42 cents per barrel (1¢/gal.) more than his operating margin. As long as the costs of pollution control plus any other cost disadvantage of domestic refiners were below this 1 cent per gallon protection, no deleterious impacts would be expected.[1] If this were combined with a provision exempting plants less than (say) 10,000 barrels per day from paying the imported crude oil fee for the first "X" barrels per day purchased, no negative impacts on small refineries would be indicated (even in the long run) - provided that their total cost disadvantage (pollution control plus other costs) does not exceed the protection offered by the fee structure.

Cost of Pollution Control

Air. Since a significant portion of the pollution abatement expenditures to be incurred by the refining industry are due to requirements under the 1970 Clean Air Act Amendments, these costs should also be presented. Recent EPA estimates of air pollution control costs are as shown below:

Air Pollution Control Costs, 1973-80[2]
(Existing and New Facilities - $MM)

	Capital Investments[3]	Annualized[4]	Cost/Barrel
Existing Refineries	$577	$148	3¢
New Source	322	18[5]	1-1/4¢

1) By waiving the (21 cents per barrel) import fee on crude oil, protection could be increased to 1.5 cents per gallon.
2) Source: Cost of Clean Air 1974, EPA.
3) Plus or minus 25%.
4) O&M + amortization @ 10% over 15 years.
5) Includes annual cost savings from hydrocarbon storage.

Water. EPA estimates the following costs of water pollution control:

Water Pollution Control Costs ($MM)

	Capital Investment	Annual Total	Annual ¢/Bbl.
1977-Existing Sources[1] (Best Practicable Technology)	$1,112	$449	8.9
1983- (Best Available Technology)	625	250	5.0
New Source Standards (by 1977)	75	26	0.5

The total annual cost to be incurred by 1977 is $475 million ($449 + $26) or about 9.4 cents per barrel, and 14.4 cents per barrel by 1983.

Unit Cost Increases. The above discussion illustrates that the average cost of water pollution abatement is well below the 1 to 1-1/2 cents per gallon (42-63¢/bbl.) subsidy that was available under the license fee system. Cost pressures are 9.4 cents per barrel cost for 1977, together with the total air pollution control cost of 4-1/4 cents per barrel.[2]

1) Includes estimate of in-plant modification costs.

2) These costs for air pollution control are annual costs through 1980. However, the largest portion of capital expenditures is estimated to occur prior to 1978, and the use of the 4-1/4¢/bbl. figure should not appreciably overstate average unit cost.

II. FINANCIAL EFFECTS

A. Effects on Profitability - Industry Aggregate

As we have discussed previously, refinery profitability data are unavailable, but we have estimated refinery margins for typical plants. Our previous estimates (in Part I) of operating costs indicated that "typical" costs for a plant manufacturing fuel products averages about $2.70 per barrel excluding raw material and $10.70 including them. If we assume gross refinery gate "revenues" of $10.70 per barrel of product ($0.25/gal.), pre-tax net income would, on this basis, have been roughly 50 cents per barrel or about one-half of the capital charges shown on the fixed and variable cost exhibit in Part I of this report. Thus, if a refinery were unable to pass on these costs, the total air and water pollution abatement costs (just under 14 cents per barrel) would cut this margin for a typical refinery by about 25 percent (but would wipe out all net income for a small refiner).

It is likely, however, that a substantial part of these costs will be able to be passed on in the form of higher prices. This is because the industry is expanding. Consequently, prices must be high enough to make expansion profitable. And the costs of expansion include at least the air and water pollution costs associated with additions to product outturns. Only to the extent that per-unit-of-output costs of pollution abatement are higher for existing plants than for new plants or plant expansion should we expect refiners to absorb pollution abatement costs out of profits.

B. Effects on Profitability - By Refinery Characteristics

Although we have demonstrated above that on the aggregate the added costs of pollution control will not greatly

affect the industry's profitability, certain classes of refineries will be affected to a greater degree than the previous analysis indicates. Two basic characteristics have a large impact on the effect of water pollution abatement costs on refineries - size and water use.

1. The effects of size on pollution control costs. Since the size of petroleum refineries varies from small plants with capacities of 2-3,000 barrels per day to large complexes with thruputs of over 400,000 barrels per day, economies of scale play an important part in an impact analysis. Figure 2 illustrates the varying impact of water pollution costs by refinery class (categories according to complexity) and size. As shown by these curves, the effect of the scale economies becomes most pronounced within the range of refineries with less than about 25,000 barrels per day of crude throughput. Since half of the refineries in the United States are 25,000 barrels per day or less (but represent only 8 percent of refining capacity), this size makes a good cut-off point for this analysis. An analysis of a 25,000 barrels per day refinery yields air pollution control investment costs of $1.74 million, or about 4 cents per barrel on an annualized basis. Water pollution control requirements (excluding in-process changes) will place an added burden of at least 9 cents per barrel on the same refinery by 1977 (and an additional 6 cents per barrel by 1983). The total 1977 small refinery burden of 13 cents per barrel is about one-fourth of the estimated mid-1973 profit margin. Thus, although profiability for this refinery will be impaired by pollution control costs, as long as modest protection (through price controls, import protection, etc.) is provided, the magnitude of this impact will not require the refinery to close. The addition of the cost of in-plant changes to the analysis does not change this conclusion.

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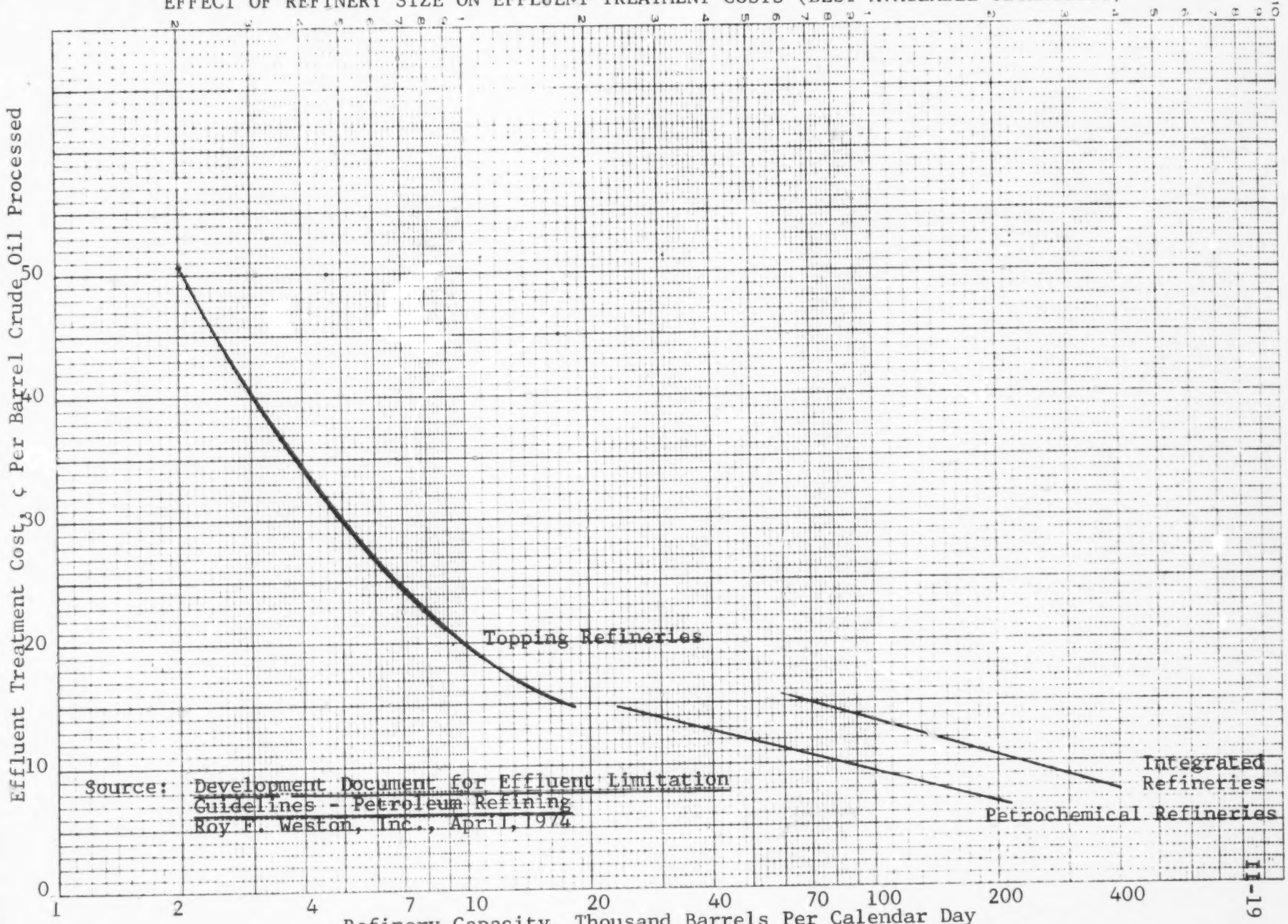
FIGURE 2

EFFECT OF REFINERY SIZE ON EFFLUENT TREATMENT COSTS (BEST AVAILABLE TECHNOLOGY)



Source: Development Document for Effluent Limitation Guidelines - Petroleum Refining Roy F. Weston, Inc., April, 1974

a. Refineries greater than 25,000 barrels per day. In the calculation above, it was found that a hypothetical refinery of 25,000 barrels per day capacity can continue to operate profitably in compliance with new standards. For several reasons the larger the refinery, other things being equal, the greater its cost advantage.

First, the economies of scale favor larger installations. The EPA estimates that a completely new plant to treat 10 million gallons per day of water would cost only 19 times as much as one to treat 0.1 million gallons per day (one hundredth as much). This is an exponential scale factor of about 0.65, which is typical of oil processing units as well.

Further, because of the larger absolute amounts involved, it is profitable for larger refineries to install relatively more equipment to recover heat used in the refining process. Since much of the water consumed by a refinery is used for cooling, the more heat recovered the less water used (though heat may also be rejected to air). There is an offsetting effect in that smaller refineries generally produce a lower fraction of processing-intensive products (gasoline and lubricating oil), and, therefore, use less heat per unit processed.

Also, because of the absolute magnitudes involved, it is profitable for a larger plant to conserve relatively more water.

Finally, larger refineries are probably already closer to full compliance with environmental standards than are smaller ones. There are several reasons for this. The pollutants discharged from a large refinery may have been large enough to have generated pressure for control in the past. Moreover, larger refineries are more clustered than small ones. This amplifies the

effects of pollutants and the pressure to eliminate them. Some small refineries, on the other hand, are in rather isolated areas where environmental problems in the past may not have been of high concern.

We conclude that on the basis of their size, refineries with a crude oil distilling capacity of 25,000 barrels per day or more should encounter no difficulty in operating profitably due to new control costs. We shall, therefore, give our attention hereafter to the smaller plants.

b. Refineries less than 25,000 barrels per day. As seen in Figure 2, the effect of economies of scale on this range of refineries is much greater than refineries in the larger size categories. Thus, even assuming an average profitability for these refineries, one expects to find a dramatically greater impact from pollution control costs on their profitability. Table II demonstrates the approximate economic effects of pollution abatement cost on various size ranges of smaller refineries.

In the absence of protective measures, these costs could have a substantial impact on small refineries. Previously, these refineries, even including their import tickets, were running very close to break-even (i.e., under the import quota system, which provided small refineries approximately 1/2 cent per gallon added revenues, operating revenues equalled operating costs), and, therefore, had a very low "going-concern value" -- the dollar value of the refinery as it continues in operation. Subsequently, under the fee system scenario, the 42 cents per barrel revenue increase (62¢-21¢) due to import tariffs greatly enhances the small refinery's going-concern value. By way of illustration, assuming a 12 percent capitalization rate over 4 years (to account for the high degree of risk associated with the long-term future of this incentive) a break-even refinery will

TABLE II

POLLUTION CONTROL COSTS OF SMALL REFINERIES

Capacity (Bbls./Day)	Investment					Annual		
	Air		Water - BPCT		Total			
	$MM	$/Bbl./ Day	$MM	$/Bbl./ Day	$/Bbl./ Day	Air ¢/Bbl.	Water ¢/Bbl.	Total ¢/Bbl.
25	1.74	$ 70	1.96	77	147	4	9	13
15	1.22	81	1.58	106	187	4.5	11.5	16
10	.91	91	1.31	131	222	5	14	19
5	.57	114	1.01	202	316	6	30	36

have a minimum going-concern value of approximately $485[1] per daily barrel (new refineries with a yield of products of above-average value could be built for about $1400 per daily barrel in 1971[2]). Scale economies greatly affect the magnitude of pollution control costs. But under these assumptions the costs of pollution control (even for the very small refineries) would not dictate a decision to shut down on a going-concern-value basis.

2. The effects of water-use characteristics on effluent control costs. The above analyses have been carried out assuming water pollution treatment costs based on hydraulic loadings which were assumed to be representative of the median water use for each class of refinery recycling all cooling water. In some cases refineries combine cooling and process waters at various points in the operation, such that the final effluent discharged is many times that of recycling refineries.

A recent survey taken by the American Petroleum Institute and the Environmental Protection Agency reveals the following ranges of water use within each refinery category:

1) ($.42/bbl.x365) ÷ (.316 capitalization factor) = $485. The 42¢/bbl. factor used is based on the fee system cushion that was provided a small refinery. In the current situation, one could justifiably use a much larger factor. This would, of course, lend further support to the suggestion of continued economic viability of most refineries.

2) Oil Daily, October 12, 1971

Refinery Water Use

Category	Water Use (Gal./Bbl.) Min.	Median	Max.	EPA Effluent Guidelines Basis
A	2.17	18	620	12
B	4.12	40.4	6861	17-21*
C	5.53	42.6	1188	25
D	22.2	47.3	644	37
E	26.9	86.9	1691	-

* In the proposed effluent guidelines Category B was separated into two groups on the basis of cracking as a percent of thruput. Two water use bases were developed for these categories.

Figures 3 through 7 show the distribution of these ranges for each category as reported by the API/EPA survey.

The difficulty in this analysis is in obtaining additional data on the costs to these high-water-use refineries above the end-of-pipe "typical" costs presented by the technical contractor.[1)] Figure 1 presented the costs of reducing effluent water flow. Using this data we can approximate the total expenditures that would be incurred by the "high water users." Table III calculates combined costs of end-of-pipe treatment and reduced water usage for small refineries. In these calculations, waste water flow was not permitted to be reduced below 7 gallons per barrel of crude oil processed, a minimum achievable rate recommended by the technical contractor for BAT. Also, the minimum cost for in-plant flow reduction was arbitrarily set at the extrapolated cost of reducing flow by 0.1 million gallons per day.

1) Roy F. Weston, Inc., op. cit.

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FIGURE 3

DISTRIBUTION OF WASTE WATER FLOW

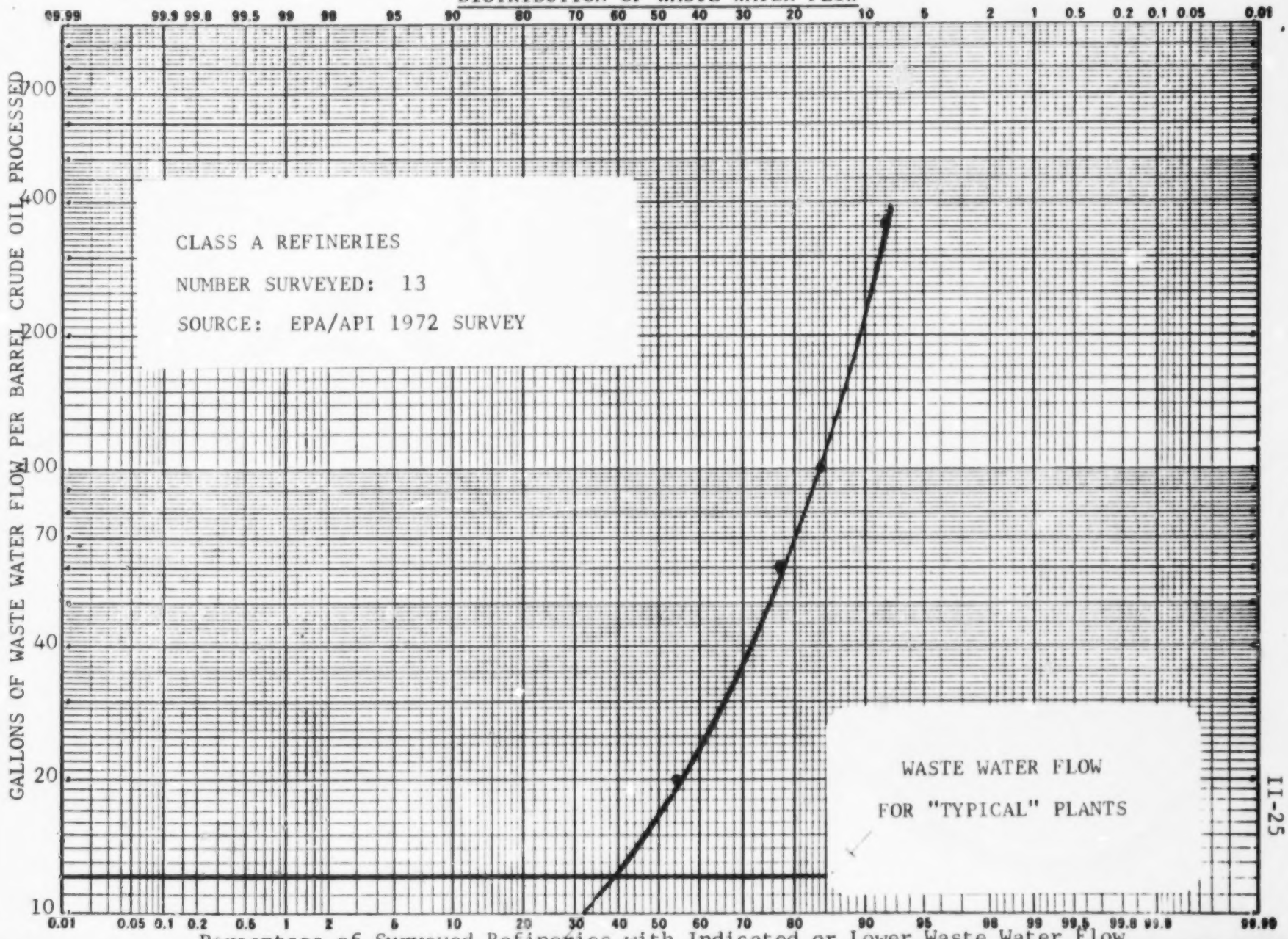
99.99 99.9 99.8 99.5 99 98 95 90 80 70 60 50 40 30 20 10 5 2 1 0.5 0.2 0.1 0.05 0.01
GALLONS OF WASTE WATER FLOW PER BARREL CRUDE OIL PROCESSED
700
400
200
100
70
40
20
10
CLASS A REFINERIES
NUMBER SURVEYED: 13
SOURCE: EPA/API 1972 SURVEY
WASTE WATER FLOW
FOR "TYPICAL" PLANTS
0.01 0.05 0.1 0.2 0.5 1 2 5 10 20 30 40 50 60 70 80 90 95 98 99 99.5 99.8 99.9 99.99
Percentage of Surveyed Refineries with Indicated or Lower Waste Water Flow

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FIGURE 4

DISTRIBUTION OF WASTE WATER FLOW

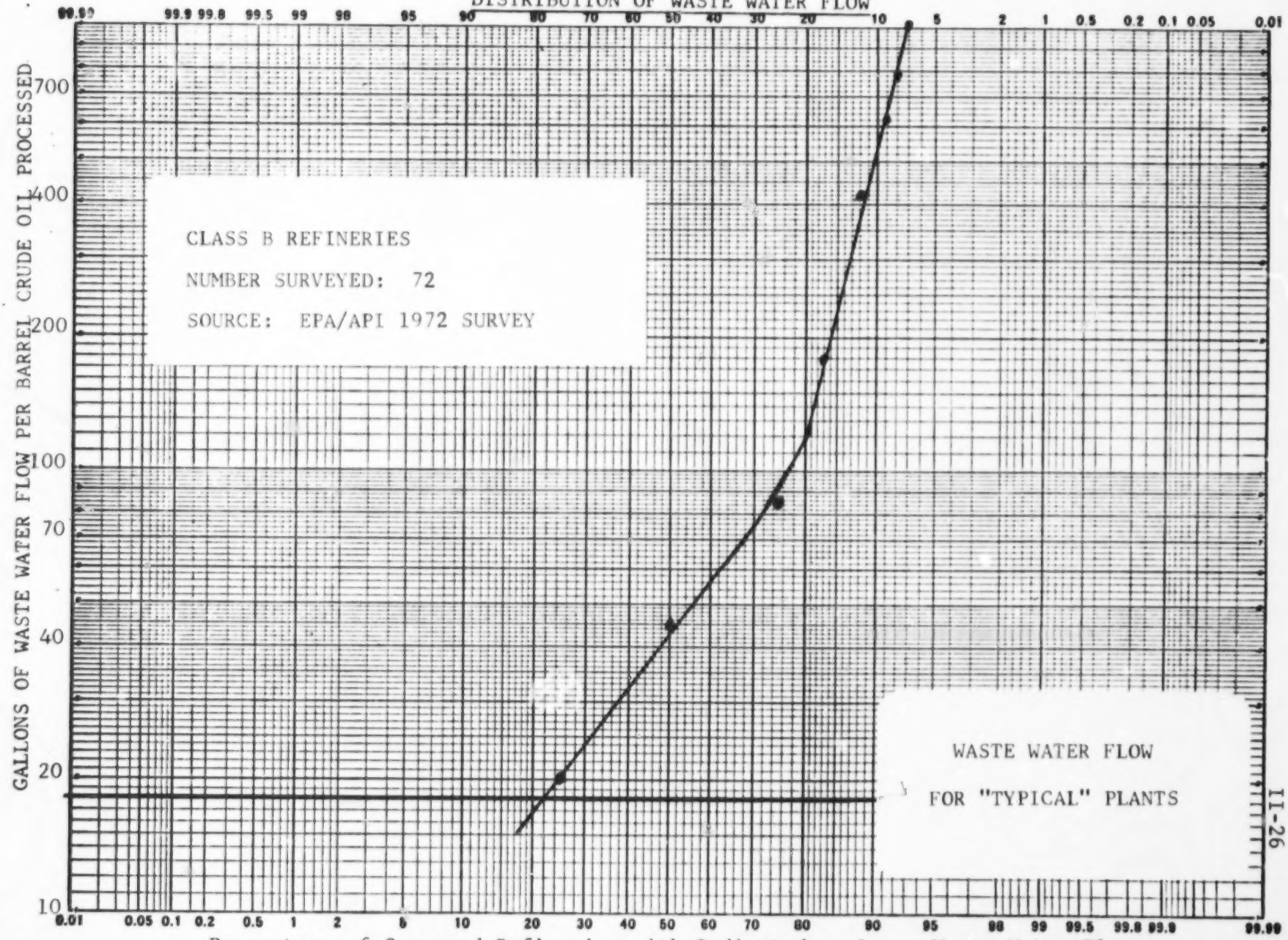
99.9 99.8 99.5 99 98 95 90 80 70 60 50 40 30 20 10 5 2 1 0.5 0.2 0.1 0.05 0.01
GALLONS OF WASTE WATER FLOW PER BARREL CRUDE OIL PROCESSED
700
400
200
100
70
40
20
10
CLASS B REFINERIES
NUMBER SURVEYED: 72
SOURCE: EPA/API 1972 SURVEY
WASTE WATER FLOW
FOR "TYPICAL" PLANTS
0.01 0.05 0.1 0.2 0.5 1 2 5 10 20 30 40 50 60 70 80 90 95 98 99 99.5 99.8 99.9 99.99
Percentage of Surveyed Refineries with Indicated or Lower Waste Water Flow

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FIGURE 5

DISTRIBUTION OF WASTE WATER FLOW

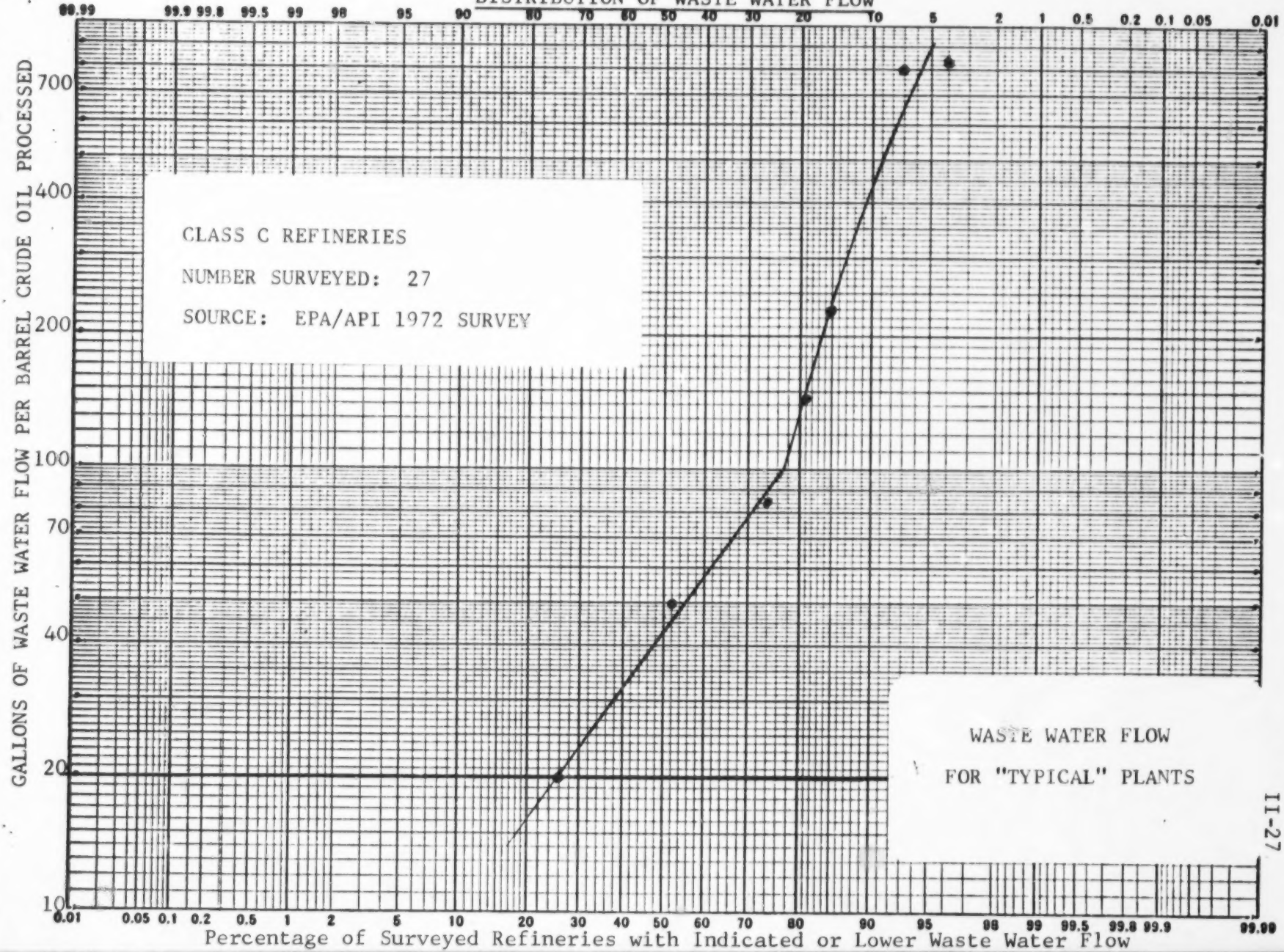
99.99 99.9 99.8 99.5 99 98 95 90 80 70 60 50 40 30 20 10 5 2 1 0.5 0.2 0.1 0.05 0.01
GALLONS OF WASTE WATER FLOW PER BARREL CRUDE OIL PROCESSED
700
400
200
100
70
40
20
10
CLASS C REFINERIES
NUMBER SURVEYED: 27
SOURCE: EPA/API 1972 SURVEY
WASTE WATER FLOW
FOR "TYPICAL" PLANTS
0.01 0.05 0.1 0.2 0.5 1 2 5 10 20 30 40 50 60 70 80 90 95 98 99 99.5 99.8 99.9 99.99
Percentage of Surveyed Refineries with Indicated or Lower Waste Water Flow

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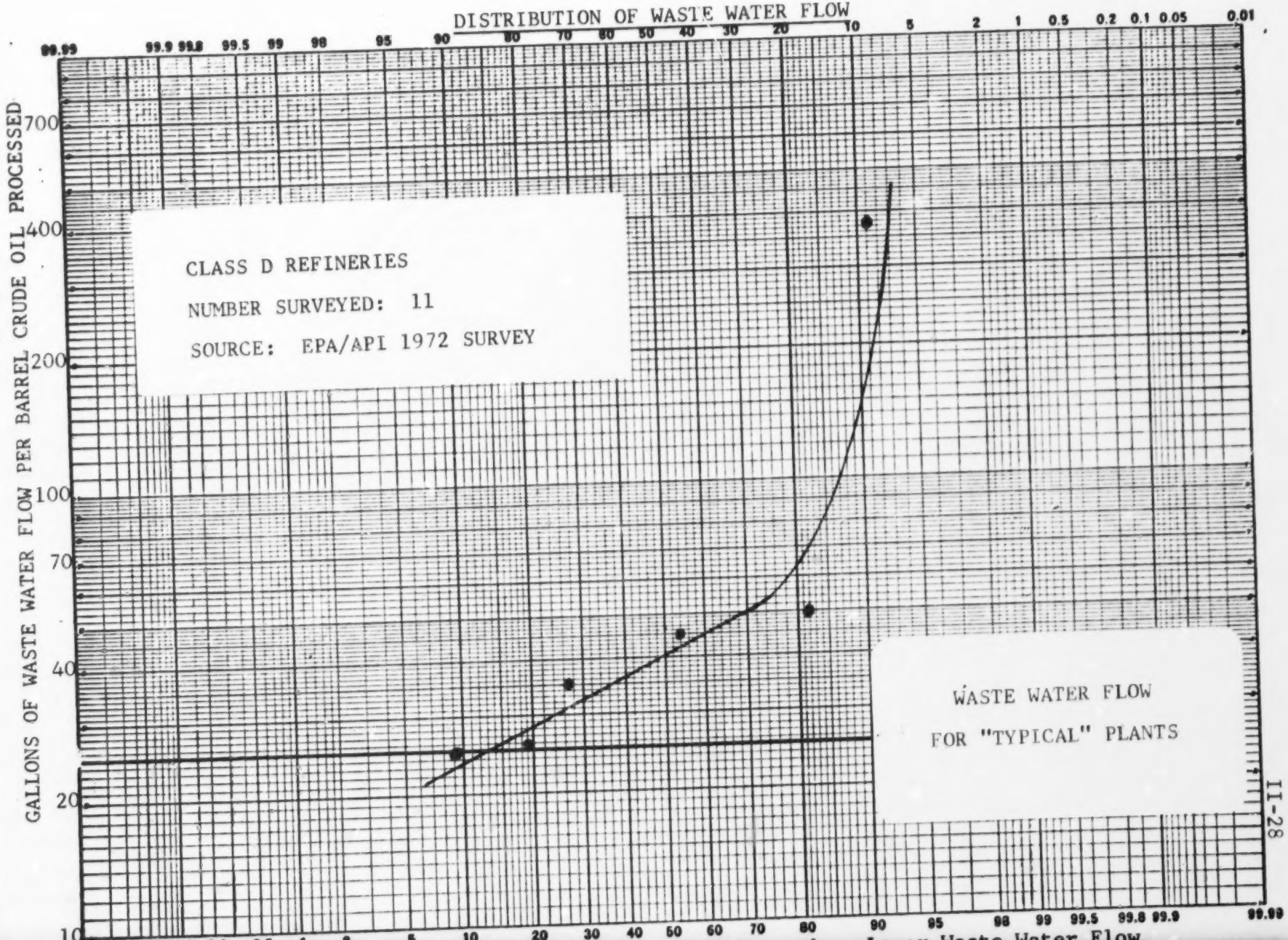
FIGURE 6

DISTRIBUTION OF WASTE WATER FLOW


99.99 99.9 99.8 99.5 99 98 95 90 80 70 60 50 40 30 20 10 5 2 1 0.5 0.2 0.1 0.05 0.01
GALLONS OF WASTE WATER FLOW PER BARREL CRUDE OIL PROCESSED
700
400
200
100
70
40
20
10
CLASS D REFINERIES
NUMBER SURVEYED: 11
SOURCE: EPA/API 1972 SURVEY
WASTE WATER FLOW
FOR "TYPICAL" PLANTS
1 2 5 10 20 30 40 50 60 70 80 90 95 98 99 99.5 99.8 99.9 99.99
Percent Less Than Indicated Waste Water Flow

NO. 3 [illegible] LOGARITHMIC [illegible] OBABILITY. DESIGN[illegible] D BY HAZEN, WHIPP[illegible]E & FULLER. [illegible] KEUFFEL & ESSER CO. [illegible] INDEX BOOK COMPA[illegible], INC. NORWOOD, [illegible]ASSACHUSETTS. PRINTED IN U.S.A.

FIGURE 7

DISTRIBUTION OF WASTE WATER FLOW

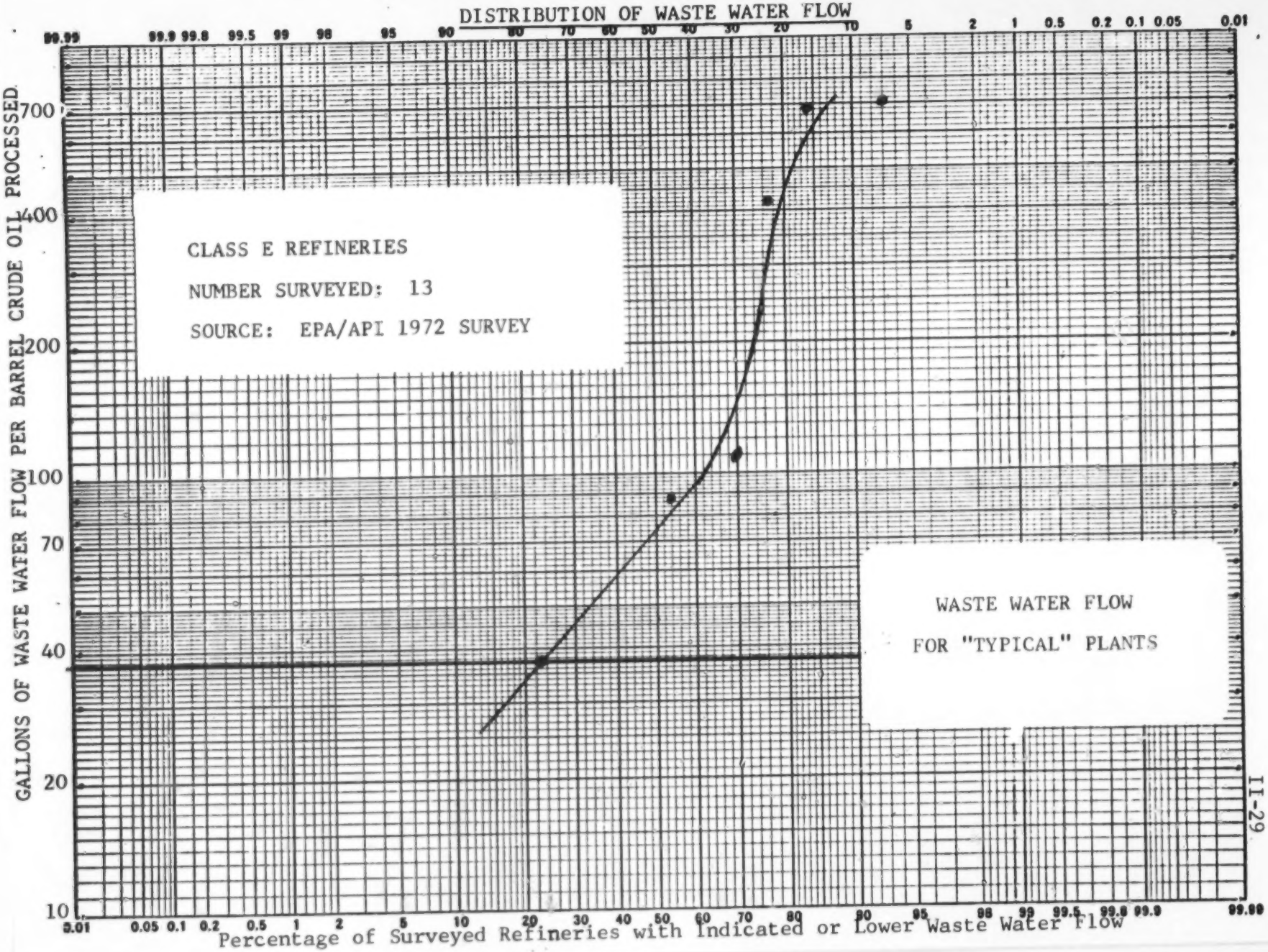

99.99 99.9 99.8 99.5 99 98 95 90 80 70 60 50 40 30 20 10 5 2 1 0.5 0.2 0.1 0.05 0.01
GALLONS OF WASTE WATER FLOW PER BARREL CRUDE OIL PROCESSED
700
400
200
100
70
40
20
10
CLASS E REFINERIES
NUMBER SURVEYED: 13
SOURCE: EPA/API 1972 SURVEY
WASTE WATER FLOW
FOR "TYPICAL" PLANTS
0.01 0.05 0.1 0.2 0.5 1 2 5 10 20 30 40 50 60 70 80 90 95 98 99 99.5 99.8 99.9 99.99
Percentage of Surveyed Refineries with Indicated or Lower Waste Water Flow

TABLE III

"EXAMPLE" OPTIMUM COSTS (END-OF-PIPE PLUS IN-PROCESS) TO TREAT REFINERY WASTE WATER TO FWPCA STANDARDS (CENTS PER BARREL CRUDE OIL PROCESSED)[1]

Level of Treatment	In-Plant Cost Extrapolation Identification[2]	Waste Water Flow Before In-Plant Modifications gallons per barrel crude oil process			
		7	22	100	500
1. 2,000 barrels per calendar day refinery					
BPCT	a	16¢	23	38	64
	b	16	21	24	46
BAT	a	32	49	54	80
	b	32	38	40	57
2. 6,000 barrels per calendar day refinery					
BPCT	a	8	11	21	35
	b	8	10	13	25
BAT	a	16	22	29	43
	b	16	18	22	34
3. 18,000 barrels per calendar day refinery					
BPCT	a	4	6	10	19
	b	4	5	8	15
BAT	a	8	11	15	24
	b	8	10	12	20

1) In these calculations waste water flow was not allowed to fall below 7 gallons per barrel, a minimum achievable rate recommended by the technical contractor for BAT. Also, the minimum cost for in-plant flow reduction was arbitrarily set at the (extrapolated) cost of reducing flow by 0.1 million gallons per day.

2) Figure 1

3. Capital availability. In comparison with other industries the 1977 pollution control costs appear to be very large. Nonetheless, the following factors argue that even this amount will not in aggregate significantly reduce the industry's ability to attract new capital for expansion:

a. 1973 capital expenditures for the petroleum refining industry totalled about $1 billion.[1] The required annual expenditure for water pollution abatement during 1973-1976 is only 28 percent of this figure.

b. The industry itself claims water pollution control capital expenditures in 1972 totaling $288 million.[2] The capital required by 1977, spread equally over four years, is only slightly more than $200 million annually.

Unfortunately, we cannot evaluate the capital availability question for individual refineries or companies since the data are not readily available. For a particular small refiner, this could be a problem - whether for refinery modification and expansion or for pollution control expenditures.

1) Financial Analysis of a Group of Petroleum Companies, 1973, The Chase Manhattan Bank, N.A.

2) Environmental Expenditures of the United States Petroleum Industry 1966-1972, American Petroleum Institute. Publication 4176.

III. PRODUCTION EFFECTS

A. Plant Closings

Since production curtailments in this industry would more than likely be associated with plant closings, only the potential for the latter will be examined. From Table III, Table IV was computed for "example" refineries falling into the critical ranges dictated by the preceding analysis. Since data on water use and costs of water conservation are scarce, this table is only meant to show relative magnitudes and should in no way be taken as an actual prediction of plant closings.[1] However, it may be safe to conclude that, given the above costs and analysis and the current level of federal concern over refining capacity, very few, if any, refineries will close because of pollution control.

It should be noted that the cost of making changes in product qualities that come about as a result of environmental regulations will weigh more heavily on the "example" refineries than will the costs of water discharge regulations. This may be particularly true of regulations on lead in gasoline, which will have a significant impact on small refineries that do not have cracking capabilities.[2]

B. Effects on Industry Growth

We have calculated that the New Source Standards will add roughly an additional $31 per barrel per day capacity to the cost of a new refinery. With new refineries requiring capital of at least $1500-2000 per barrel per day capacity, the added burden appears to be too small to act as a deterrent to growth.

1) The computations were based on the assumption of a license fee "cushion" of 42¢/bbl.

2) Stephen Sobotka & Company, "The Impact on Small Refineries of Lead Content in Gasoline Regulations," Working Paper prepared for EPA in 1973.

TABLE IV

"EXAMPLE" NUMBERS OF THREATENED REFINERIES

Refinery Capacity Range, thousand barrels per day	0/2	2/4	4/7	7/10
Number of Refineries in Class	13	17	35	13
Waste Water Flow Requiring "Example" Abatement Cost in Excess of 42 cents per barrel[1] gallons per barrel	35	230	700	1700
% of Refineries in Class with This, or Greater, Waste Water Flow	43	17	8	Nil
Number of Refineries Jeopardized by Waste Water Control Costs	5	3	3	-

1) For refinery size at class median; i.e., 1.0 MB/D, 3.0, 5.5, 8.5

IV. EMPLOYMENT AND COMMUNITY EFFECTS

If we assume (at worst) that our "example" threatened plants in Table IV actually close, employees exposed to potential job losses would be approximately 100-500 out of a total of 150,000 refinery workers. Since these refineries are located in several geographical areas, the concentrated regional and community impacts of these potential job losses would be minimal. Localized secondary impacts on the affected communities would, of course, occur.

V. BALANCE OF TRADE

The United States is becoming more and more dependent upon foreign crude. This trend is expected to continue for at least a few years. However, only if free competition (Scenario #1) equilibrates world and domestic prices of crude and products would environmental control expenditures have a negative effect on the future balance-of-payments for petroleum products.